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1911—Nos. 1 and 2.

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(Animal Product Series, No. 3.)

THE

AGRICULTURAL LEDGER

1911—No. 1.

GUANO.

Bat and Bird Guanos in India.

BY I. H. BURKILL.

DEPOSITS RARE

It is well known that bat and bird guanos are used as manures in India where available, but the supply is very small. The following sums up all the information which has been brought together by an enquiry recently undertaken.

Bat or bird guano only accumulates in suitable caves, and they are generally rare in India. More of such caves are to be found in Tenasserim than in any other part of the country: there the curious abrupt limestone hills which rise out of the alluvium are often perforated by long winding caverns whence bat dung is extracted for use. Similar caverns occur from South-Western China to the Malay States and doubtless in many parts of the Malay islands. Ceylon also possesses bat caves.

Tenasserim caves.

The bat guano caves of Tenasserim are the property of Government and the rights of extracting the guano from the larger caves are sold yearly, or from the smaller caves at suitable intervals. The following table gives the amount of guano extracted and the revenue realised by the sale of the collecting rights.

Statement showing the Quantity of Bat's Guano collected and revenue realised therefrom in the Thatôn, Amherst, Tavoy and Mergui districts during the past six years.

Name of of District.	Year during which collected.	Quantity collected in baskets.	Purpose for which collected.	Amount of revenue realized.	If used locally, at which rate sold.	Any other information that may be of interest.
1	2	3	4	5	6	7
				Rs.		
Thatôn . .	1903-4	5,000	..	2,360	Rs. 50 per 100 at Hlaingbwe cave and Rs. 75 at Pagat.	It is collected for the purpose of manuring vegetables. One basket of guano equals to 25 lbs. These figures are exclusive of the quantities that might have been collected from the Kyauktaing, Kyaikdeyon, Kawgun and Mizaing caves.
	1904-5	4,600	..	2,360		
	1905-6	4,500	..	2,360		
	1906-7	4,500	..	2,275		
	1907-8	17,222	..	2,905		
	1908-9	5,400	..	3,465		
Amherst .	1903-4	..	..	..	..	The Kayon, Sadan and Damathat caves have very small deposits. The deposits in the Winpok and Paya caves near Kyrikmaraw are larger. The weight of a basket in Amherst is reported to be 8 viss or 28·8 lbs.
	1904-5	2,200	..	640	..	
	1905-6	2,100	..	420	..	
	1906-7	3,000	..	655	..	
	1907-8	2,900	..	680	..	
	1908-9	2,800	..	880	..	
Tavoy . .	1903-4	..	Exported to Moulmein for manure in gardens	..	..	It is not annually collected though found in considerable quantities in Southern and middle Moscos of Launglon township. The weight is not known.
	1904-5	..		..	..	
	1905-6	..		..	..	
	1906-7	546		50	..	
	1907-8	..		..	..	
	1908-9	200		390	..	
Mergui . .	1903-4	1,500	..	400	14 annas per basket.	It is chiefly used as a manure for garden cultivation. Collection is made in and among hill caves of Upper and Lower Tenasserim and in parts of Bokpyin township. The weight of a basket varies from 45 to 50 lbs.
	1904-5	2,050	..	500		
	1905-6	2,000	..	300		
	1906-7	800	..	400		
	1907-8	..	..	390		
	1908-9	800	..	390		

The guano extracted is used chiefly by Chinamen on the gardens where vegetables are raised; it is also used largely for manuring plantations of durian (**Durio Zibethinus**).

CHEMICAL COMPOSITION

So far as has been ascertained there is at present little, if any, export of the substance to other countries.

As is the case with all guanos there is probably great variation in the composition of samples obtained from different places.

In the Agricultural Journal of India (vol. iv, 1909, pp. 379—81) analyses are given of three samples of guano obtained from near Kyaukse.

No. I, the new deposit, was of a dry, powdery consistency, and on examination numerous particles of the elytra of beetles and the hard outer coverings of other insects were easily distinguishable; in fact, it had the appearance of being composed of the ground-up, hard parts of insects.

No. II was an older deposit and had not the same powdery nature as No. I, but was largely solidified, darker brown in colour, and the remains of insects, though still to some extent recognisable, were not so easily distinguished.

No. III, the oldest deposit obtained, was practically one solid mass, and when dug out was in large lumps. It was of a still darker brown colour and the insect remains were difficult to discern.

The following analyses, made by the Agricultural Chemist, Mandalay, give an idea of the manurial value of these three samples :—

Result of analysis of guano (Cave deposits).

	Sample No. I, Upper deposit.	Sample No. II, Middle deposit.	Sample No. III, Lower deposit.
Moisture	15·38	3·73	2·69
Dry Substance—			
* Ash	28·00	52·85	71·94
† Combined water and organic matter	72·00	47·15	28·06
	100·00	100·00	100·00
* Containing :—			
Percentage on dry matter—			
Phosphoric acid	2·13	1·06	1·62
Potash	·76	·68	·59
Lime	7·89	1·23	1·68
Magnesia	1·55	1·06	·98
Ferric oxide	2·02	2·35	3·90
Sand	13·89	45·34	63·43
† Containing Nitrogen	7·97	4·37	·63

CHEMICAL COMPOSITION.

Analyses of guano from the Federated Malay States were made in 1905 by Professor Dunstan. Professor Dunstan had four samples. Sample A had been taken from the limestone caves at Padang Rengas in Perak, about 16 miles from Taiping : it was dark buff in colour and contained small white fragments of calcium sulphate and phosphate. Samples 1-3 had been taken from the Batu Caves at Selangor in the Federated Malay States : the first had been taken from within three inches of the surface and was reddish-brown ; the second had been taken from a depth of six inches and was dark brown ; the third had been taken from the depth of one foot and was light yellowish-brown. Analysed, the following figures were obtained :—

	A. Per cent.	No. 1. Per cent.	No. 2. Per cent	No. 3. Per cent.
Silica	8·42	31·62	19·79	21·77
Alumina	2·56	11·36	10·78	10·70
Ferric oxide	1·75	11·03	9·05	8·28
Manganous oxide	·31	·20	·19	·13
Lime	22·27	1·81	1·86	2·52
Magnesia	trace	1·03	1·04	·95
Cupric oxide	·34	·37	·35	·34
Potash	2·01	1·12	·88	·88
Soda	1·30	·78	·75	·79
Ammonia	·58	·12	·14	·12
Nitric acid	7·55	·81	·91	·86
Phosphoric acid	17·52	8·60	10·86	14·17
Sulphuric acid	16·32	·41	·53	·50
Chlorine	·13	trace	trace	..
Combined water	4·36	2·91	2·62	2·24
Moisture	9·59	21·26	22·92	26·60
Organic matter	4·88	6·57	17·21	9·62
Total nitrogen	2·47	·81	1·52	·84
Phosphoric acid soluble in water	·81	..	..	..
Phosphoric acid soluble in ammonium citrate solution	3·25	7·38	8·54	9·75

The analyses are only moderately instructive because the deposits of guano evidently contained many fragments of rock from the cave walls.

Professor Dunstan comments on the analyses as follows :—

" These guanos are comparatively rich in phosphoric acid, of which a fairly large proportion is....in a form in which it could be utilised by plants : they are deficient in....potash and nitrogen .... The best of the four bat guanos is sample A, which contains 2 per cent. of potash, 2·47 per cent. of nitrogen in the form of ammonium nitrate, and 17·52 per cent. of phosphoric acid in the form of ferric, aluminium and calcium phosphates ..... The phosphoric acid content of this guano would be worth about £2 16*s*. per ton in this country (England), and it is unlikely

that the small amount of 'Nitrogen' and potash present would enhance its commercial value. This price is undoubtedly too low to permit of profitable export and it would probably prove more remunerative to employ the guano locally." VALUE.

Professor Dunstan notes that the phosphoric acid content increases downwards.

He obtained from dealers in guano the information that similar samples of guano had been brought into England from Mexico, Borneo, Algeria, Jamaica and elsewhere, but had not been received with favour.

I find recorded in my office the results of the examination of a sample of guano from Upper Burma (locality of origin not recorded). The sample was very deficient in nitrates, none being present in the form of salts of ammonia; and I think it had been indiscriminatingly taken from some spot where water had been able to wash those salts out.

On the whole then both by reason of the smallness of the supply and because the material is not in demand in Europe, the supply must be used up locally. It would probably be of great interest to see if the guano is now used in the most economical way; for it is evident that the vegetables it is used to stimulate need to obtain nitrogen from other sources, and if the soil is not rich in these, the phosphates of the guano are superabundant.

The deposits of bat's guano in India proper appear to be practically confined to those of the Kurnool and Nellore districts in the Madras Presidency. Deposits in Madras.

The earliest recorded mention of them is to be found in a report on Experimental Farms, Madras, 1883, p. 10 :—

"The existence of large deposits of bat guano in a cave called Yerrayari situate in the Banganapalle jaghire in the Kurnool district was brought to notice during the year by Mr. Bruce-Foote of the Geological Survey of India. Mr. Bruce-Foote said that he found it being carted by a party of melon-growers from Chennoor, a village in the Cuddapah district 75 miles off. Enquiry showed that its value as a manure was but little recognised locally. From a quantitative analysis of it for this Department by the Chemical Examiner, it would appear to be a most valuable manure, being particularly rich in ammonia. There are similar deposits of guano in caves under the Dolphin's Nose, a promontory on

DEPOSITS IN MADRAS.

the North-East coast close to Vizagapatam, but the caves are practically inaccessible, and the deposits are but little drawn upon."

The next recorded notice of this guano occurs in the following passage from the Manual of the Kurnool district by Narahari Gopala Kristnamah Chetty, 1886, p. 164 :—"Bat guano is sometimes used in melon beds in the Kundur river. Recently it has been applied to paddy crops also with good results."

The Board of Revenue, Madras, reported in 1909 that "small quantities of guano have been found in the hills and caves of Nandyal and Koilkuntla taluks and in some of the reserved forests in the Markapur taluk, and that they to some extent are used as manure for melon gardens." And that the Collector of Nellore, on the authority of the District Forest Officer, had ascertained that fifteen cartloads of guano (bats' manure) can be collected annually in the Udayagiri and Kanigiri reserves whence it is still taken to Cuddapah for manuring melons.

DEPOSITS IN BOMBAY.

Apparently a very small quantity of bat's dung is available in the hills of the Bezwáda range. A small deposit occurs on the southern coast of Káthiáwár, but owing to the difficulty of access the price is prohibitive.

DEPOSITS IN THE NICOBARS.

In the annual report on the Nancowry Settlements, Nicobar Islands, for 1870-71, page 6, it was reported by Mr. G. H. Man that 3 or 4 ship-loads of guano could be got off the island of Katschall, and a far more extensive accumulation from Great Nicobar. Thirty bags were sent to Port Blair for report ; but the results are not recorded. In the second and only other report published (being for the year 1871-72), page 5, Mr. J. N. Homfray, the Assistant Superintendent in charge of the Nicobars, alluded to the caves on Katschall island, and the guano in such a way as to make it evident that nothing more had been done.

In his "Text-book of Indian Agriculture," vol. v, page 190, Mr. James Mollison mentions the Nicobars as a source of guano, adding that the guano had found a use in Assam on tea gardens. I assume from this remark that some one had meanwhile shipped to Calcutta from the Nicobars a supply of guano of which I find no record.

Kloss in his book "In the Andamans and Nicobars" (London, 1903), p. 26, mentions the guano caves of Little Nicobar thus :—"In the rocky hill .... we discovered several caves, which run inwards from mouths situated at the water's level. These are

the homes of thousand of tiny leaf-nosed bats (**Hipposiderus nicobarulae,** sp. nov.), and immense numbers of the bird's nest swift (**Collocalia linchi**). The largest of these caves is about 50 feet deep and 20 feet high at the entrance ; but at the back the accumulation of guano is so great that there is barely room to stand. As we entered with our lantern, our feet sinking ankle-deep into the soft chocolate coloured floor, there was a continual rush of little bats and birds overhead as they sought to escape .... The rock at the back was covered with countless numbers of the shallow cup-shaped nests of saliva-gummed moss. So closely were they built that in many cases one could not place a finger tip on the rock between them, and often they were constructed one on the side of the other. Fortunately for the birds, they are builders of the green variety of nests ; for had there been white they would not long have remained undisturbed by the Chinese.... In the cave, the swallows breed at the inner end while the bats congregate near the mouth. Another small cave was inhabited by bats only." DEPOSITS IN THE NICOBARS.

The Chief Commissioner and Superintendent, Port Blair, has been so kind as to cause enquiries to be made regarding such guano deposits as Kloss mentions. They do not appear to be extensive enough to be a commercial asset. In the northern islands no guano was found, and in the central and southern islands but a thin deposit in caves where the swallows breed. A report sent to me by Lieutenant-Colonel H. A. Browning, under the date 30th March 1910, stated that no deposit of commercial value could be heard of.

There is a large cave at Shwe-male not far from Mandalay ; but it apparently yields no guano. Deposits are found along the range of hills bordering on the Shan States and dividing them from the plains of the Irrawaddy. Near Kyaukse guano is reported to exist in a broad cleft between the rocks to an unknown depth, said to be several hundred feet. DEPOSITS ON THE EDGE OF THE SHAN HILLS.

Mr. LaTouche informs me that the extensive limestone caves of the southern face of the Garo Hills house great colonies of bats near their mouths, but the wash of water during the rains sweeps any deposit away.

There are guano caves in the Peshāwar district. In the Gazetteer of the district, edition of 1883-84, a cave is mentioned under the Pushtu name of Kashmir Smats, as existing near the summit of the Sakri ridge of Pajja, eight miles north-west of Bazar in DEPOSITS IN THE PESHAWAR DISTRICT.

DEPOSITS IN MADRAS.

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DEPOSITS IN THE PESHAWAR DISTRICT.

DEPOSITS IN THE PESHAWAR DISTRICT.

the tappah Sadhum, but best approached from Babazai in the tappah Bazai, which General Cunningham had identified with Huien Tsang's "Cave of Prince Sadana in mount Dantalok." The cave, it is said in that Gazetteer, had not been thoroughly explored: its neighbourhood was full of ruins. As recorded in the Gazetteer of the district, edition of 1897-98, the cave was afterwards made more accessible by a pony road from Pirsai; and it had been explored. The limestone was found to have been cut into three chambers of considerable length, the third of which, 80 feet high and above 80 feet in diameter, with an opening in the roof, held there a deposit to a depth of several feet of pigeons' and bats' dung. This cave had been a shrine.

Enquiry from the Deputy Commissioner, Peshawar, obtained for me information kindly sent by Mr. L. M. Crump, I.C.S., Assistant Commissioner, Mardān District, that the nearest villages are remote from the cave and the dung finds no use. He continued "there are some very small deposits near Hamza-kote which are used by the Khan of the village as manure in his garden ..... and caves with small deposits at Kamtro Gut near Chayuli, Tarrale Dara near Sikri, and Sikri-Dara near Shakar Tanji. None of the deposits are of any appreciable extent.... Except the very small deposits at Hamza Kote, none are used regularly owing to the distance of the places from villages and difficulties of access and transport."

GUANO a medicine in Baluchistan.

Bats' guano is a drug in parts of Baluchistān under the name of Kam-yaft. Mr. R. Hughes-Buller sent it to me as such in 1903 from the Pab hills, with the information that it is taken for gonorrhœa in the form of a draught.

DEPOSITS IN CEYLON.

In January 1908, Mr. J. A. Daniel visited the nitre cave at Wellawaya, Uva, and sent an interesting description to Spolia Zeylanica, vol. v, p. 107. This cave is mentioned by Dr. John Davy in his "Account of the Interior of Ceylon" (1821), page 429. The surroundings of the cave are scarcely changed. The cave is in the heart of a forest about $2\frac{1}{2}$ miles from the Koslanda-Wellawaya road. The number of bats was enormous, and the floor of the cave was covered with the excrement of the bats to a depth of five feet. Much of the manure had been converted into saltpetre by chemical decomposition. Davy states that this cave was worked for many years for saltpetre by a party of natives who came annually from Passora for the purpose. The economic

Saltpetre Manufacture.

value of tons of manure available in this and several other caves is yet to be proved. DEPOSITS IN CHINA.

The Chinese supply alluded to in the first sentences of this note comes from Chiung Chou near Chengtu in Szechuan and finds its use as a medicine under the name of Yeh-ming-sha (*vide* Hosie, Report on the Province of Ssuch'uan, 1904, p. 51). I have not been able to find that any is used to help on the intense cultivation of the plain of Chengtu.

Many works of travel in China speak of caverns. Gill for instance (The River of Golden Sand, London, 1880, I, p. 347) says of country quite close to Chengtu "There were a great many caves and caverns in the sides of the hill." And a little further on he writes of limestone cliffs. While Jack (The back-blocks of China, pages 48 and 116) mentions sandstone caves—as occurring on the south of Chengtu. But neither these nor any other authors that I have consulted definitely say anything about the source and supply of bats' guano from them.

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THE

AGRICULTURAL LEDGER

1911—No. 2.

EDIBLE FROGS.

Edible Frogs in India.

BY I. H. BURKILL.

MADRAS FROGS.

It is, I believe, not uncommon for frogs to be served up in the restaurants of Pondicherry. The species there used, Dr. Annandale tells me, is **Rana tigrina.**

Rana tigrina is also extensively used in Burma, where frogs under the name of Sa-hpa are sold in the Bazaars fresh and dried. Besides **Rana tigrina,** several other species are eaten in Burma, and some others are said to be eaten in Madras.

There is a note in Sir George Watt's " Chief Indian Animal Products " (Simla, 1902), page 55, that Mr. Thurston had seen frogs hung up for sale in the Cochin bazaar : and in the same place it is recorded, from the " Madras Mail " of August 1873, that the lower class people of Madras and Tinnevelly eat, besides **peria tavalei,** which is probably **Rana tigrina,** three others called **patchei tavalei, sori tavalei** and as the greatest of delicacies **manal tavalei.**

Dr. J. R. Henderson, Central Museum, Madras, has kindly sent me the following identifications.

MADRAS FROGS.

"Patchei thavalai" (green frog)=**Rana hexadactyla,** Lesson, the common tank frog of Southern India.

"Sori thavalai" (itch frog)=**Bufo melanostictus,** Schneid., the common Indian toad, popularly believed to produce itch when handled.

"Munal thavalai" (sand frog) or "mun thavalai" (mud frog) =**Cacopus systoma,** Günth., the commonest of burrowing frogs in Madras."

Dr. Henderson thinks it doubtful if the two last are used as food, but in the light of what will be said later, it seems that they can be eaten, and it is, indeed, not unlikely that many more frogs than these are eaten in Madras by men who do not willingly acknowledge to it.

BURMESE FROGS.

From Burma I have received the following names:—

Hpa-aing, or the mottled frog.
Hpa-baung-she.
Hpa-baung-zin, or the spangled frog.
Hpa-byan, or the flying frog.
Hpa-byok.
Hpa-da-let.
Hpa-gon-nyin.
Hpa-kyaw-zan-ke.
Hpa-la-det.
Hpa-nan-chaung.
Hpa-zaing, or the green frog.
Saung-hpa.
Thai-hpa.

Frogs in Burma if used fresh are boiled or curried, the head and intestines having been removed, and the skin taken off after the body has been dipped into hot water: or on other occasions the frog is prepared by having the intestines removed, being flattened between bamboo rollers and then smoked: and when required for eating it is fried or cooked in other ways. The sale price of a smoke-cured frog is about one anna.

Rana tigrina, as accepted by zoologists, is a very variable species, and apparently the Burmese have different names for different varieties, which require study before we understand them. The commonest frog seems to be that with a long thin white line from the mouth down the spine and with a relatively smooth skin. To it,

in Burma, the name Hpa-zaing seems to belong. The frog can be caught at any season. BURMESE FROGS.

Equally to naturalists the specimens sent to me as Hpa-boung-zin seem to be **Rana tigrina,** but my letters described it as of very different habits, burying itself in the bunds of the paddy fields in the dry weather, and being taken when it has emerged after the first rains. The identity of Hpa-boung-zin is therefore somewhat doubtful. The name Hpa-boung-zin is of very wide use in Burma, and the frog is extensively eaten in almost every district that has sent reports.

Hpa-da-let, eaten in Minbu, is probably an immature state of Hpa-zaing. It is said not to be much relished and seldom sold at least in the Minbu district.

Hpa-boung-she is a frog of the same size as **Rana tigrina** which Dr. Annandale has named as **R. burkilli** (Records of the Indian Museum, vol. v., 1910, page 79). It is somewhat warted, wants the long thin white line and is more obtuse in the snout. Specimens have been sent to me from Prome, Bassein and Tavoy—from Prome as Hpa-boung-she, from Bassein under the common name of Sa-hpa, and from Tavoy associated with the first form under the name of Hpa-zaing.

Hpa-da-let has been named for me by Dr. Annandale as **Rana limnocharis.** It is a frog by no means unlike **Rana tigrina** in appearance, having its somewhat acute snout, but differing in the white line down the back being broad. I have only received it from Prome.

Thai-hpa is a small species of Rana from Minbu, found about sandy streams and not much eaten. Probably it is immature. I have smoked bazaar specimens of Saung-hpa and Hpa-byan from Minbu, but cannot suggest a name for them. The first is a cold weather frog, not much sought after : the second is a very active whitish frog found during the rains and not much relished.

Hpa-gon-nyin is a name applied always to species of **Callula** and particularly to **C. pulchra,** Günth. The Burmese name has been received from several districts, *viz.*, Minbu, Prome, Bassèin and Mergui. It is a frog of the rains and collected about the paddy fields during the wet season. The Burmese name means the Entada-scandens frog—because its round dark body resembles the large dark-brown seed of **Entada scadens**. It is said to be eaten

BURMESE FROGS.

considerably in Prome. In the dried bazaar specimens of Hpa-nan-chaung from Minbu, which is all at my command of this frog, I can see no marks to distinguish it from **Callula pulchra,** but judged by the note sent to me saying that it is collected at night by means of a light in May and June and is much sought after for eating (which Hpa-gon-nyin is not in Minbu), it must be different.

Hpa-aing of Minbu is a frog very unlike any others, recognised at once by its small head, for which Dr. Annandale has suggested the Genus **Cacopus.** It is considered the best to eat of all the frogs and sells at Rs. 1-4 per viss of 3·65 lbs. It appears after the first showers of the rains in the jungle.

All the above are edible frogs, the toad Hpa-byok (**Bufo melanostictus**, Schneid.) is not reported as eaten in Burma and its skin is said to be poisonous; but Dr. Annandale believes that its flesh is eaten in Lower Siam.

FROGS FROM NEPAL.

Dr. Annandale informs me that a Nepāli recently was seen by him in Calcutta trying to sell a stock of dried **Rana liebigii,** Günther, which he had collected, so he said, "from under the snows" in the mountains of Nepāl. The bodies are eviscerated and dried, and a soup is made from them which has certain medicinal virtues.

FROGS OF THE NAGA HILLS.

Nāgās apparently regularly eat frogs. Mr. W. J. H. Ballantine, Haflong, informs me that the Nāgās and Rāngkhol and Jungsoen l'engta (or naked) Kukis in the North Cāchār Hills eat three species of frogs which are plentiful at the beginning of the rains. They are eaten freshly cooked, but if a large number are caught at a time, they are dried and kept and eaten like dried-fish.

The specimens of edible frogs sent by Mr. Ballantine were identified by Mr. S. W. Kemp as :—**Rana tigrina,** Daud., **R. limnocharis,** Wiegm., and **Rhacophorus leucomystax,** Bouleng.

Frogs are also known to be eaten by the Chinese, at any rate in the north of China.

SUMMARY.

The zoologists who may refer to this note will find the following summary useful :—

Rana tigrina, Daud. More eaten than any other Indian frog and used in the French restaurants of Pondichery. It is called Peria tavalei in Madras, and Hpa-Zaing, and perhaps Hpa-boung-zin in Burma. The tribes of North Cāchār eat it.

SUMMARY.

Ranaburkilli, Annandale. A frog similar in size and appearance to R. tigrina, which is eaten in Burma under the name of Hpaboung-she.

Rana limnocharis, Weig. Similar in size to the last two, and eaten in Burma as well as by the tribes of the North Cāchār Hills. The Burmese call it Hpa-da-let.

Rana hexadactyla, Lesson, called patchei thavalei in Madras, is said there to be eaten.

Rana liebigii, Günth. Collected in Nepâl, and made into a medicinal soup.

Rhacophorus leucomystax, Bouleng., is eaten by the tribes of the hills of North Cāchār.

Callula pulchra, Günth., is eaten in Burma under the name of Hpa-gon-nyin.

Cacopus systoma, Günth., is the munal thavalei or mun thavalai said to be eaten in Madras.

A frog apparently belonging to the genus Cacopus is eaten in Central Burma and considered very good to eat. It has been received from Minbu under the name of Hpa-aing.

Bufo melonostictus, Schneid., is the sori thavalei or itch frog of Madras, and the Hpa-byok of Burma. It is reported by one writer as eaten in Madras.

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THE

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GLYCINE HISPIDA.

SOY BEAN.

THE SOY BEAN IN INDIA.

BY DAVID HOOPER.

INTRODUCTION.

The original home of the Soy bean plant (**Glycine hispida**, Maxim., **G. Soja,** Sieb. and Zucc.) is the extreme east of Asia, and it has been long cultivated all over the east between Japan and Java. According to Aiton it was introduced into England in 1790, and according to Professor Church it has met with some successful cultivation in Europe since 1873. Notwithstanding its recommendations the Soy bean has never been cultivated to any considerable extent in England and the continent of Europe. The plant was introduced into the United States of America in 1854 and was grown to a small extent in the Southern States, but from the year 1885 its cultivation as a forage crop has gained in importance in all the agricultural centres. Within the last two or three years a great deal of interest has been taken in the cultivation of Soy, and experiments are in progress in Government Farms in Cape Colony, Natal, East Africa, Gambia, Mauritius and Australia.

It is difficult to ascertain the date of the introduction of Soy beans into India. There is no doubt that certain hill tribes, mostly of Mongolian origin, have cultivated the bean for a long time. At the Punjab Exhibition held at Lahore in 1864 Soy beans identified by Dr. Cleghorn, were sent from the Hill States. This is the first record of the beans being exhibited in this country, and shows that the cultivation was on an insignificant scale.

Experiments in India.

EXPERIMENTAL CULTIVATION IN INDIA.

In 1882 Messrs. Jardine, Matheson & Co. of Hong-Kong sent a sample of Soy beans for experimental cultivation in the Saidapet Experimental Farm, Madras. The plants raised from these seeds were healthy but the yield of the crop was small.

Madras.

In 1897 Surgeon-Colonel W. G. King, Sanitary Commissioner, Madras, strongly advocated the cultivation of Soy bean as a valuable food worthy of the attention of the people. In two experiments carried on at Saidapet during 1897-98, the yield of seed per acre was 468 to 495 lbs., respectively. Recent enquiries in Madras resulted in the opinion that the cultivation in the Presidency is still in an experimental stage.

United Provinces.

In 1882 some Japanese Soy beans were sent by the Government of India for trial to Sahāranpur. In 1885 very good results were obtained, the black seeded variety giving a yield of 1,124 lbs. per acre, and the white seeded variety giving a yield of 561 lbs. per acre. In 1886 the acclimatised seed was widely distributed; in some cases the crop failed and in others it was fairly successful, but as a rule where seed was harvested it was said that the pulse was not popular in any form. The Botanical Gardens grew the crop for a few years longer but as there was no demand for the seeds the cultivation was abandoned. An interest in Soy bean, however, seems to have revived for the Agricultural Department has this year sent to the Reporter on Economic Products samples of the black variety of Soy beans from forty villages of the United Provinces.

Central Provinces.

At the Experimental Farm at Nāgpur, Central Provinces, the bean was grown experimentally from Japanese seed first planted in 1885. The yield at the end of the first year was at the rate of 180 lbs. per acre, but taking the average of five years the result was 88 lbs. per acre. In the Report for 1908-09 it is stated that Soy beans were grown on a small area under field conditions and the yield was fair, but there was little local demand for the seed. It was, however, ground and formed an excellent addition to the diet of the farm cattle. Last year only 43 lbs. were obtained on light soil on the Nāgpur Farm, the crop being practically a complete failure; on heavier soil 380 lbs. of seed were raised.

Bombay.

Soy beans have been grown at Poona for nine or ten years with varying results, and they have also been tried at Nadiād in Gujrāt and elsewhere in the Bombay Presidency. In the Experimental Farm Report for 1901 a large yield was chronicled, but next year the crops at Poona and Surat failed. In 1904 a yield of 300 lbs. per acre was obtained in light land. One year later nineteen plots were under trial

EXPERIMENTAL CULTIVATION IN INDIA.

but with unpromising results, for only five yielded seed enough to repay the cost of cultivation. The yield varied from 50 to 293 lbs. per acre, and it was found that only when the yield exceeded 200 lbs. was the crop profitable. In 1905-06 the Manjri Farm, Poona, grew nineteen plots with better results, probably due to better soil. The yield of some of the plots was on an average of 680 lbs. per acre—a highly remunerative return. A year later it was reported by Mr. Fletcher, Deputy Director of Agriculture, that an experiment made on the edge of black cotton soil gave a yield of 1,166 lbs. per acre, while adjacent plots gave from 395 to 650 lbs. per acre.

Panjab.

In the Agri.-Horticultural Gardens at Lahore Soy bean planted on a small area in 1894 yielded an estimated crop of 349 lbs. of seed per acre and 349 lbs. of fodder. Evidently it varies greatly in suitability to different soils and climates and does not seem to be adapted to the sea level plains of India.

Gollan observed that the Japanese plant is erect, attaining a height of 12 to 15 inches, while the Himālayan form is a trailing plant. So far this vigorous growing plant does not appear in India to have been attacked by any insect or parasitic fungus.

NAMES.

With regard to Burma Mr. Burkill remarks: "The Burmese grow it under the names of Pe-nga-pi and Pe-kyat-pyin, sowing it never in great quantities along with other beans on the mud banks as the falling rivers leave them bare in October, or more sparingly still away from the rivers. The Kachins and other hill tribes grow a little of it on their hill clearings, the Kachins call it Lasi. The Khāsis, the Nāgās and other tribes between the Brahmaputra and Upper Assam cultivate it similarly.....In the Brahmaputra Valley it is grown as far as known only towards Barpeta in the Kāmrūp District."

Soy beans are called "Bhut" in the Punjab, "Bhat", "Bhatwas" or "Bhatmas" in the United Provinces and in the hills as far as Darjeeling, and "Rymbai ktung" in Shillong and the Khāsi Hills. Mr. B. C. Basu gives the Assamese name for **Glycine** as "Patani jokra" and the corresponding Bengali name as "Chhai." In the Nāgā Hills it is called "Tsudza" or "Sudza." It is grown by the Lepchās in Sikkim and is called by them "Salyang" or "Silliangdun." "Pe-nga-pi" is the usual name for Soy bean in Burma, but it has been received under the name of "Lasi shapre tum" from Bhamo, and as "Lasi N'Loi" and "Lasi N'Hti" from Myitkyinā. The Santālī name appears to be "Disom Horee."

Cultivation.

METHOD OF CULTIVATION.

Soy bean is generally grown by itself as a kharif (rainy season) crop. The seed is sown in June or July and the crop is ripe in September or October, or three months afterwards. The seeds should be placed at a depth not exceeding 1 to 1½ inch. Eighteen plants to the square yard may be left after weeding. The plant prefers a peaty soil or one rich in organic matter; a calcareous soil is also favourable to its growth. Potassium sulphate or chloride is a good manure. Under ordinary circumstances it is not necessary to use any nitrogenous fertiliser as sufficient of this element is usually present in the soil, and like other legumes, this plant assimilates the free nitrogen of the air.

When grown for seed it has been found that half to three-quarters of a bushel, or 15 to 20 lbs., per acre is ample. When sown broadcast or drilled in rows very little cultivation is required. A slight harrowing when the plants are young is all that is necessary. If the drills have not been made too far apart it will be found that the plants will soon shade the soil sufficiently to keep the weeds in check and the surface in good condition. It is well known that the cultivation of leguminous crops enriches a soil in its available nitrogen content ; certain nitrifying bacteria attack its roots forming tubercles, and these are capable of transforming the nitrogen of the atmosphere into nitrogenous compounds fit for absorption by plants.

When the Soy bean was first introduced into the United States it did not form root tubercles owing to the absence of the particular kind of bacteria in the soil, and in some places the tubercles were not developed though cultivated for a number of years. In other soils which evidently contained the necessary bacteria, the tubercles were developed from the beginning. A soil not containing the bacteria should be inoculated, that is to say some bacteria must be introduced.

Green manure.

The value of a crop used as a green manure depends on two things : first, the addition of nitrogen to the soil, and second the condition in which it leaves the soil after cultivation. It has been found in the United States that although Soy bean compares very favourably with other leguminous plants as the cowpea and clover as regards the first point, it does not leave the soil in as good a condition as the clover. It has been recommended that when a crop of Soy bean is turned under for green manure it must be well limed. This will obviate the bad effects sometimes experienced when a very heavy crop of legumes is ploughed under.

METHOD OF CULTIVATION.

The Soy bean is largely employed in Japan as a soil renewer and is cultivated in rotation with cereal crops. An economical method of growing Soy bean, adopted in Japan, is to sow it between rows of maize. Two crops are thus obtained at once, besides which the soil is enriched by the increase of nitrogen. This method could no doubt be extended in India and used with some prospect of success in the cotton districts of Bombay and in the tea gardens of Assam.

Harvesting.

The time for harvesting the Soy bean crop necessarily depends upon the use for which the crop is intended. Under ordinary conditions the earlier varieties will mature in 75 to 90 days from the time of planting. It is desirable, however, in harvesting the crop for seed to cut before the pods are quite ripe, if they become too ripe, they will burst open in drying and a portion of the seed may be lost. If the green portion of the plant is to be used for feeding purposes it is a good practice to cut when the pods are half mature, as in that case the hay will contain a larger amount of digestible nutriment and will be much more palatable than if allowed to stand until the pods are thoroughly mature.

The amount of forage obtained from Soy bean will of course vary widely according to the conditions under which the crop is grown. Under favourable circumstances as much as 12 or 13 bushels of fresh fodder may be produced per acre, and 25 to 40 bushels of seed. It has been shown under the head of experiments that from 500 to 1,000 lbs. of seed per acre may be obtained in India in a good year.

RACES AND VARIETIES.

The different races of the Soy bean are distinguished according to the colour of the seeds and shape and size of the pods. Dr. C. D. Harz, in his "Landwirthschaftliche Samenkunde," Berlin, 1885, adopted a botanical arrangement of the Soy plants so as to include all the then known forms of seeds. Two so-called race-groups and eight races are thus enumerated.

Race-group. **Soja platycarpa,** Harz., flat fruited.

1. **olivacea,** Harz., olive-brown Soy beans, weight of 100=15·04 grammes.
2. **punctata,** Harz., punctated Soy bean.
3. **melanosperma,** Harz., black-seeded, long Soy bean, weight of 100=14·25 grammes.
4. **platysperma,** (**S. compressa nigra,** M.) black, flat Soy bean.
5. **parvula,** Martens, seed as above, but smaller.

Race-group. **Soja tumida,** Harz., swollen fruited bean.

6. **pallida,** Roxb. (**S. sphærica rivescens,** Mart.) Pale, yellow, yellowish, greenish-yellow bean, weight of 100=11·7 to 25·69 grammes.

RACES AND VARIETIES.

7. **castanea** (**S. elliptica castanea,** M.) brown Soy bean, weight of 100=8·15 to 16·76 grammes.

8. **atrosperma,** Harz. (**S. sphærica nigra** and **S. sph. minor,** Mart.) Black seeded, weight of 100=16·30 to 21·0 grammes.

For the classification prevalent in Manchuria, the following arrangement is taken from "Manchuria, its people, resources and recent history" by Sir Alexander Hosie (1904) :—

Yellow bean (Haung-Tow)	(*a*) White eyebrow.
	(*b*) Golden yellow.
	(*c*) Black belly.
Green bean (Ching-Tow)	(*a*) Epidermis green, inside yellow.
	(*b*) Epidermis and inside both green.
Black bean (Wu-Tow)	(*a*) Large, inside green.
	(*b*) Small, inside yellow.
	(*c*) Flat, inside yellow.

In the Province of Szechuen in Western China the following well-marked varieties of Soy beans are cultivated :—

1. Yellow Soy bean.

(*a*) White yellow bean (Pai Huang Tou). This is the lightest coloured of the yellow beans. They are ovoid in shape, not much larger than the common pea and weigh 150 to the ounce (100 seeds=18·88 grammes). As a rule they are cooked whole and served as a vegetable.

(*b*) Large yellow bean (Ta Huang Tou).—There is a slight tinge of green in these beans which are larger and heavier than the preceding. 122 weigh one ounce (100 seeds=23·22 grammes).

(*c*) Small yellow bean (Hsiao Huang Tou).—This kind has the same ovoid shape but is much smaller than the others. 266 weigh an ounce (100 seeds=10·65 grammes). It is extracted from *a* and *b*, while *c*, which is less expensive, is in demand for making bean-curd.

2. Green Soy bean (Ching Tou).—There are two kinds of this bean, one in which the epidermis and inside are both green and the other in which the inside is yellow. It is of the same size, shape and weight as the white yellow bean (100 seeds=18·88 grammes). Both kinds are cooked and eaten as a vegetable and are also salted and put away in jars for winter use.

The yellow and green varieties of Soy bean occupy the ground from April to August, whereas the black kind takes much longer to mature.

3. Black Soy bean (Hei Tou). Of this there are two kinds— RACES AND VARIETIES.

(*a*) The first is much larger, rounder and heavier than the yellow and green varieties. Only eighty-eight weigh one ounce (100 seeds=32·19 grammes). Like the green beans it is used cooked in its fresh state as well as pickled.

(*b*) This is a small flattish bean; about 450 going to the ounce (100 seeds=6·29 grammes). It is used principally in medicine, also for food. Both the forms are black outside and yellow inside, the testa of the former being readily detachable when crushed.

Races in India.

It will be seen from the foregoing that there is a large variety of Soy beans in cultivation in China and Japan. At the Universal Exhibition held at Vienna in 1873 there were 13 varieties exhibited, differing according to shape, size and colour. M. A. Paillieux, author of "Le Soya, sa composition chimique, ses variétés, sa culture et ses usages," (Paris 1881), concludes that there are 30 varieties of the pulse. RACES IN INDIA.

The following are the results of an attempt to classify the different varieties of Soy beans collected together in the office of the Reporter on Economic Products to the Government of India.

First of all the seeds are classified under four heads according to their colour, *viz.*, Yellow, Green, Black, Brown and Mottled. These are again subdivided according to their weights, which have been ascertained by Babu S. C. Mukerji, M.A.

A.—The Yellow Races.

I. Large Yellow Soy Bean. They are globose seeds, one hundred weighing from 21·40 to 21·64 grammes. They have been grown in the Poona Experimental Farm, most probably from the Chinese seeds known as Te Huang Tou or Large Yellow Bean. Yellow seeds

II. Pale Yellow Bean. These are globose yellowish seeds but smaller than the preceding (100 seeds=16 grammes on an average). They seem to be Pai Huang Tou (White Yellow Bean) that have been introduced into Poona. One sample comes from Northern Shan States, Burma (100 seeds=17·62 grammes).

III. Small Yellow Soy Bean. They too are globose or ovoid in shape but one hundred of them weigh only about 10 grammes on an average. (The weight varying from 9 to 12 grammes.) They were mostly

RACES IN INDIA.
Yellow seeds.

obtained from the Experimental Farm of Poona and seen to be Hsiao Huang Tou (small yellow bean) of China. One sample comes from Haka, Chin Hills, Burma (100 seeds = 9·49 grammes) and another from Kalimpong, Darjeeling (100 seeds = 9·24 grammes).

IV. Smaller Yellow Soy Bean. These samples are elliptical in shape and 100 seeds weigh on an average about 7 grammes. The seeds have been received from Tiddim, Chin Hills, Burma; Kalimpong, Darjeeling; Kathā, Burma; Chakrātā, Dehra Dūn; and Simla, Punjab.

V. Smallest Yellow Soy Bean. They are elliptical or reniform in shape and very small, 100 seeds weighing from 3·5 to 5·9 grammes. They come mainly from Burma.

B.—The Green Races.

Green seeds.

The ovoid green beans are grown in Poona from Chinese seeds but they have become smaller in the plants naturalized in India, one hundred weighing from 11·24 to 15·68 grammes (whereas 100 seeds of the Chinese Green race weigh 18·8 grammes). T epidermis of the seed only is green, the interior being yellow.

C.—The Black Races.

Black seeds.

In these races, the epidermis only is black, the inside is yellow.

I. The large globose race, is represented by a sample from Poona, evidently grown from Chinese or Japanese seed. But 100 seeds weigh 21·5 grammes whereas 100 seeds of the Chinese variety weigh 32·19 grammes.

II. The Small Black Soy Bean. This bean with flattish elliptical seeds is comparatively largely grown in various districts of the United Provinces and Patna Division as well as on the lower slopes of the Himālayas from Kashmīr to Darjeeling. Their weight indicates the plant to be the same as is known in China as the smaller-seeded of the two races called together Hei Tou (Black Bean); 100 seeds weigh 4 to 6 grammes. This has been cultivated for a long time by the natives of India.

It is observed, moreover, that the races of this small black Soy bean that are grown in hilly places like Kashmīr, Simla, and Darjeeling have heavier seeds than those grown in the plains of the United Provinces and Patna. The average weight of 100 seeds of five samples from the hills is found to be 6·5 grammes whereas the average weight of 100 seeds of eleven samples from the plains is 5 grammes only. This illustrates the fact that the plant growth is affected by the situation.

D.—The Brown Races.

RACES IN INDIA. Brown seeds

I. The Large Brown Soy Bean. There is a sample from Kalimpong, Darjeeling, of large globose seeds (100 seeds = 24·66 grammes); this is the heaviest of all the samples of Soy beans in the Museum collection.

II. The Small Brown Soy Bean. They are flattish, elliptical in shape and are grown in the Himālayas from Kashmīr to Darjeeling. The weight of 100 seeds varies from 7 to 8·5 grammes; the average weight in five samples is 8 grammes.

E.—The Mottled Races.

Mottled seeds

There only one sample of this yellow and brown race obtained from Shillong. The seeds are elliptical in form and 100 seeds weigh 10·15 grammes.

Both the brown and mottled races have their epidermis only so coloured, the interior being yellow. They are not described in the above-quoted reports. They appear to have been cultivated for a long time by the natives of Assam and the lower Himālayas. The colour of the brown seeds is called "khair," from its resemblance to the colour of cutch or catechu.

Composition.

COMPOSITION OF THE SEED.

In Church's "Food Grains of India" a typical analysis is given of Soy bean presumably cultivated in the country. It contained—

Water	11·0
Albuminoids	35·3
Fat	18·9
Non-nitrogenous extractive	26·0
Fibre	4·2
Ash	4·6

Many analyses have been made of the bean grown under various names and in different countries. Several analyses are quoted in König's "Chemie der menschlichen Nahrungs- und Genussmittel," Vol. I., pp. 595-600 and 1481. An examination of the results shows that the percentage of oil in the absolutely dried seeds from different countries varies as follows :—

Chinese beans	17·60 to 26·18
Japanese	12·36 „ 25·55
Java	18·37 „ 26·18
Grown in Europe	15·16 „ 21·89
Grown in North America	18·42 „ 19·52

COMPOSITION OF THE SEED.

The average of eight analyses from China is 19·89. The average of six analyses from Japan is 20·01. The average of six analyses from Java is 21·62. The average of forty-two analyses from Europe is 18·98, being from Germany fourteen analyses with an average of 19·74, from Austria eleven, average 19·44, from Hungary six, average 19·16, from Russia nine, average 17·93, from France two, average 15·40.

In examining the Indian-grown seeds there is not much variation from the type except a slight decrease in oil in seeds from Burma and the United Provinces. Soy beans are specially rich in proteids and oil. The oil-content is rather remarkable and at once distinguishes the bean from all other pulses. Edible leguminous seeds give about 2 per cent. of oil, except the Chick pea (**Cicer arietitum**) which gives between 4 and 5 per cent.

Dr. J. W. Leather in 1903 analysed the seeds of seven samples of Soy bean from Japanese seeds cultivated at Manjri, near Poona. The amount of oil in them varied from 14·92 to 23·05 per cent. being on the dry weight 15·97 to 24·41 per cent. with an average of 19·99. In 1902 Dr. Leather examined five samples grown on the Dumraon Farm. They yielded from 14·27 to 19·72 per cent. of oil on the air-dried seeds.

Fourteen samples of the seeds grown from Japanese seeds at the Manjri Experimental Farm were again analysed last year by a leading European firm. The percentage of moisture varied from 9·90 to 12·06, and the percentage of oil from 16·80 to 22·48. Here there is no evidence of deterioration. In the opinion of a crusher to whom the samples were sent, eleven of the fourteen samples were declared to be good and six showing above 20 per cent. of oil, very good indeed and better in this respect than the best Sakura Manchurian beans which contain on an average 19·5 per cent. of oil.

Analyses made in India.

The following analyses of Indian-grown Soy beans were made in the laboratory of the Indian Museum in 1909 and 1910.

Soy Beans, Burma.

			Oil.	Oil in dry.	Water.	Ash.
31574	Haka, Chin Hills.	Yellow . .	15·20	18·53	18·0	5·3
31614	Mandalay	„ . .	10·66	15·57	12·3	5·6
31615	Bhamo	„ . .	16·14	20·45	21·1	6·4
31616	Lower Chindwin	„ . .	13·03	15·47	15·8	6·1
31619	Northern Shan States	„ . .	16·72	18·77	11·0	5·1
31620	„ „ „	with brown spots	17·35	19·73	12·1	5·5
31626	Chin Hills, yellow	. . .	17·35	19·34	10·3	6·1
31705	Northern Shan States, greenish	.	20·05	21·78	8·2	6·0

COMPOSITION OF THE SEED

Analyses made in India.

Soy Beans, Burma—continued.

		Oil.	Oil in dry.	Water.	Ash.
31706	Northern Shan States, yellowish	14·29	15·55	8·1	5·7
31707	„ „ „ „	16·49	17·88	8·3	5·7
32043	Lashio, Northern Shan States	13·96	14·93	6·5	5·9
32074	Kathā	14·5	15·6	7·0	5·5
32214	Myitkyinā "Lasi N'Loi"	15·63	16·86	7·3	4·9
32215	„ „ „	13·5	14·54	7·2	5·0
32216	„ "Lasi N'Hti"	14·8	15·94	7·2	5·1
32217	„ „ „	13·8	14·85	7·1	5·0
32265	Bhamo	11·15	12·0	6·7	5·6

Soy Beans, chiefly from Hill Tracts.

		Oil.	Oil in dry.	Water.	Ash.
31426	Nāgpur, yellowish	16·61	17·89	7·2	4·7
31565	Kalimpong, black	15·50	17·03	9·0	5·5
31566	„ white	16·51	17·83	7·4	5·5
31567	„ brown	17·25	18·98	9·1	5·6
31568	„ green	19·52	20·87	6·5	5·5
31569	„ yellowish	16·62	18·34	9·4	5·6
31577	Patna, black	14·72	17·05	13·7	5·7
31617	Shillong, white and brown	15·66	17·63	11·2	5·4
31701	Kāngra	14·25	15·47	7·9	5·9
31702	Simla, brown	16·83	18·29	8·0	5·1
31703	„ yellowish	18·09	19·57	7·6	5·5
31704	„ black	17·14	18·55	7·6	5·8
31803	Nāgā Hills, whitish	14·83	16·75	11·4	5·5
32027	Kashmīr „	16·59	17·76	6·6	4·5
32028	„ brown	14·77	15·84	6·8	4·6
32583	Trivandrum, white	16·16	18·38	12·1	5·6
32870	Darjeeling, green	17·45	19·80	11·9	5·7
32871	„ white	16·05	18·18	11·2	5·0
32872	„ yellow	17·60	19·55	10·0	5·8
32873	„ brown	16·85	19·09	11·7	5·6
32874	„ black	15·25	17·29	11·2	5·5
	Average	16·36	18·27	9·3	5·4

United Provinces, black seeds.

	Oil.	Oil in dry.	Water.	Ash.
Farrakhābād (3 samples)	15·67	16·7	6·6	4·9
Kherī (3 „)	14·95	16·0	6·5	4·4
Sītāpur (3 „)	15·80	16·8	7·0	4·5
Unao (3 „)	15·81	17·0	7·5	4·6
Fatehgarh (2 „)	15·03	16·1	6·7	4·6

United Provinces, black seeds—continued.

		Oil.	Oil in dry.	Water.	Ash.
Maīnpuri	(5 samples)	16·52	17·8	7·2	4·9
Hardoī	(6 „)	16·44	17·7	7·5	4·7
Etāwah	(6 „)	16·60	18·0	7·6	4·8
Chakrātā	(2 „)	16·75	18·0	7·1	5·6
Shikohābād	(2 „)	17·10	18·3	6·7	4·8
Lakhimpur	(2 „)	16·22	17·5	7·1	5·2
	Average	16·06	17·2	7·0	4·8

Soy Beans, Poona.

		Oil.	Oil in dry.	Water.	Ash.
31776	Yellowish	20·55	22·07	6·9	6·6
31777	„	19·50	20·86	6·5	6·2
31778	„	19·75	21·19	6·8	7·1
31779	„	20·0	21·67	7·7	7·0
31780	„	20·25	21·68	6·6	6·0
31781	Greenish	19·10	20·51	6·9	6·3
31782	„	17·30	18·72	7·6	6·1
31783	Yellowish	21·20	22·84	7·2	6·6
31784	„	18·25	19·79	7·8	6·1
31785	Black	19·10	20·73	7·9	6·1
31786	Yellowish	22·05	23·84	7·6	6·3
31787	Mixed	22·4	24·21	7·5	6·3
31788	„	19·30	21·00	8·1	5·4
31789	Yellowish	19·80	21·67	8·2	6·2
31790	Green	21·70	23·56	7·9	5·9
	Average	20·01	21·61	7·4	6·2

The oil.

Soy bean oil is largely used as food in the Far East. The oil has many other uses. Thus, in China, it is used for illuminating purposes and as it is a drying oil, it can be used in the manufacture of paints in the place of linseed oil. In Europe as well as in Eastern Asia it is employed in the manufacture of soap and as a machine lubricant.

The oil expressed from Soy beans is a favourite article of diet in Eastern Asia. Recently it has been used in the manufacture of margarine or artificial butter. The digestibility of the oil for man was studied by Korentschewski and Zimmermann in 1906. The coefficient of digestibility was found to be about 95 per cent. Thus it is seen that Soy bean oil is thoroughly assimilated.

OIL. An attempt in 1903 to extract oil from these beans with the country *ghani* or indigenous oil-mill in the usual way was a failure in Bombay. The oil is expressed by means of primitive plant in the Chinese factories The method of extraction consists in first crushing the beans into caked masses by means of mill-stones, then heating them on stone slabs until the appearance of vapours, and finally expressing them in an iron receptacle. As first obtained the oil is turbid but after some time becomes clear, the deposits consisting of sand particles and vegetable fibres. Only the clear oil is exported, but the turbid oil is sold locally. It has a faint odour recalling that of Chinese wood (tung) oil, is bland to the taste and of a dark-brown colour.

Four commercial samples examined in 1905 by W. Korentschewski and A. Zimmermann gave the following results:—Water, 0·3 to 1·80 per cent.; specific gravity at 15°C., 0·9264 to 0·9287; solidification point, 14·6° to 15·3°C.; saponification value, 207·9 to 212·6; ester value, 203·9 to 207·7; insoluble fatty acids, 93·6 to 94·28 per cent.; iodine value (Hübl) 114·8 to 137·2; solidification point of fatty acids, 16° to 77·3°C.; m. pt. of fatty acids, 20° to 21°C.; Maumené test 102° to 116° C.; and acid value, 1·86 to 15·46.

It belongs to the class of semi-drying oils, that is to say, it has properties intermediate between those of the drying oils, such as linseed oil and the non-drying oils such as almond and olive oils. On exposure to the air, a thin skin is gradually formed on the surface. It resembles cotton-seed oil in many respects, but is of a more pronounced drying character, as is indicated by its higher iodine value (the iodine value of the cotton-seed oil being 101 to 116). The oil consists mainly of the glycerides of palmitic, oleic and linolic acids.

Oil-cake.

OIL-CAKE. The Soy bean oil-cake left after the oil is expressed is a valuable cattle food, and may be substituted for the dearer decorticated cotton cake. Some cases of supposed poisonous action of the cake have been reported in England. The cause was probably due to overfeeding or admixture with noxious ingredients. Soy-bean cake being exceedingly rich and concentrated, should be used with discretion especially in the case of dairy cows. It is also used as a manure. The following analysis of the cake is taken from the Agricultural Gazette of New South Wales, Vol. XX., 1909, p. 671:—

"Moisture—14·52; ash, 5·16; fibre, 4·03; albuminoids, 42·31; carbohydrates, 25·25; other extract (fat and oil), 8·73; nutritive value, 87·3; albuminoid ratio, 1 to 1·06.

L-CAKE.

"The ash is rich in potash salts and phosphates and the manurial value is shown by the proportions of fertilising ingredients which are, as follows, in the whole cake:—nitrogen, 6·77 per cent.; potash, 2·00 per cent.; phosphoric acid, 1·33 per cent."

Soy-bean cake exported from Manchuria is stamped with the manufacturer's brand, and contains a guaranteed analysis of 6·5 per cent. of total nitrogen and 1·5 per cent. of phosphoric anhydride.

Composition of Hay.

Y.

The Soy bean is cultivated in the United States of America mainly as a forage crop and numerous experiments have been made in its growth. The following table showing the composition of the various kinds of forage made from the Soy bean (in a fresh or air dried condition) is taken from the U. S. Farmers' Bulletin, No. 58 :—

Soy bean forages.	Water.	Protein.	Fat.	Nitrogen free extract.	Fibre.	Ash.
Fodder (early bloom to early seeds)	76·5	3·6	1·0	10·1	6·5	2·3
Soy bean hay (Mass) . .	12·1	14·2	4·1	41·2	21·1	7·3
„ „ straw („) . .	11·4	4·9	1·9	37·8	37·6	6·4

Dr. Leather obtained the following figures as the average of five analyses of "bhusa" or dried green tops of Soy grown at Dumraon in 1902: water, 9·85; fat, 1·0; protein, 3·7; nitrogen free extract, 46·07; fibre, 28·44; ash, 10·94 per cent.

When dealing with the chemical analysis of the Soy-bean forage, it should be noted that the proper value of a forage does not depend on its composition only, but the digestibility of the various components must be taken into account. Quoting again from the Farmers' Bulletin, "The following rough computation will give an idea of the amount of digestible matter in the forage raised on an acre planted with this crop. Under ordinary farm conditions the yield of green fodder usually ranges from 6 to 12 tons per acre. Taking 8 tons as an average yield, the amount of dry matter will be about 2 tons, of which about 54 per cent. is digestible. This will make the digestible matter raised on an acre of ground amount to nearly $1\frac{1}{10}$ ton. Of this amount about one-sixth is protein or muscle-making material and about three-fourths crude fibre and other fat-forming substances."

Use as food.

D.

The Soy bean is very largely eaten by the Chinese and Japanese as a vegetable, and many food preparations are made from it. It is a very

important article of diet for people whose staple food is rice, a cereal very poor in proteid or nitrogenous substances. The highly nitrogenous Soy bean supplies the place of meat in European countries, and the introduction of this rich bean into the dietary of the rice-eating people of India would be a benefit to the country. AS FOOD.

Three Japanese food preparations are specially made from the bean : Soy-bean milk, Soy-bean cheese or "topo," and Soy-bean sauce or "Shoyu."

Soy-bean milk.—The Soy beans are first soaked in water for about twelve hours and then well crushed between mill-stones. The powder is then boiled with about three times its bulk of water for about an hour and filtered through cloth. The filtrate resembles cow's milk in appearance and to some extent in composition ; it is easily digestible and forms a highly nitrogenous liquid, but it is not suitable for the nourishment of children.

Bean cheese.—When Soy-bean milk is treated with magnesium chloride (or the mother liquor obtained in the manufacture of common salt from sea water) the proteids are separated in the form of a precipitate. This is collected on a filter, pressed and dried, and forms "topo" or Soy-bean cheese. It is eaten in a fresh state.

Shoyu.—Shoyu is a sauce prepared from a mixture of cooked and pulverised Soy beans, washed and powdered wheat, wheat flour, salt and water. The mass is fermented with rice-wine ferment in casks for from one-and-a-half to five years, being frequently stirred. The resulting product is a moderately thick, brown liquid. In odour and taste it is not unlike a good quality of meat extract though perhaps somewhat more pungent. Under the name of "Soy sauce" and other fanciful names it has formed the basis of most of the important sauces of Europe for many years.

Roasted Soy beans are being used in the United States and Switzerland as a coffee substitute.

The Soy bean contains little or no starch and is consequently used as a diet for diabetic patients. Bread and biscuits made from Soy-bean flour are now being placed on the European markets.

Trade.

Soy bean used to be cultivated in Manchuria to meet the demands in China and Japan, but from the year 1908, Europe has entered the field as a chief customer. During the last few years the Manchurian trade in Soy beans has prospered by leaps and bounds. The chief cause of this sudden development is certainly the last Russo-Japanese war TRADE.

RADE.

when agriculture in Manchuria was greatly stimulated as this country had to provide for the large number of soldiers located there. At the end of the war the armies were withdrawn, and Manchuria was obliged to export the surplus of its food products mainly, Soy beans.

The first large cargo of the bean reached Hull on the 2nd of March 1909, and contained 5,200 tons. Ever since then the demand for this bean has rapidly increased and British oil-crushers are setting up big machines for the bean-oil. On the continent of Europe as well as in England, a good deal of interest is being manifested in the Soy bean industry. The following facts taken from the "Indian Trade Journal," April 28th, 1910, will give an idea of the importance that this trade is rapidly acquiring nowadays.

"Up to 1907 the total exports of Soy beans from Manchuria did not exceed 120,000 tons annually. In 1908 the shipments amounted to 330,000 tons and in 1909 they ranged between 700,000 and 800,000 tons.

It is understood that large elevators are being erected outside Hull for handling the bean. This indicates that the trade is expected to be not only large but permanent; and there remains no doubt that this remarkable new trade will affect the Indian business in oil seeds."

Mr. F. E. Wilkinson, H. M. Consul at Newchwang, in his report on the trade of that district in 1909, writes :—

"In 1908, 178,000 tons of beans and 318,000 tons of bean-cake were exported from Newchwang and 438,000 tons of beans and 276,000 tons of bean-cake from Dairen, making a total of 616,000 tons of beans and 594,000 tons of bean-cake. Now as 100 tons of beans are required to produce 9 tons of oil, it may be estimated that to produce 594,000 tons of bean-cake, 653,400 tons of beans must have been treated so that the total quantity of beans represented by the combined exports of bean produce from the two ports was 1,269,400 tons. Exports from other places on the coast would bring the total exports from South Manchuria to about 1,300,000 tons".

Mr. R. M. Hodson, H. M. Vice-Consul at Vladivostok, in his report on the trade of that district in 1908 to 1909, writes :—

"The Soy bean export to Europe through Vladivostok commenced in December 1908 and shipments continued all through 1909 till October, the total amount exported to Europe being 200,000 tons. The cargo was nearly all carried in British bottoms and destined to oil mills in the United Kingdom.....The centre of the trade for North Manchuria is Kharbin and several British firms have recently opened buying agencies there."

One great advantage in Soy bean trade is that the beans arrive in Europe in a perfect condition from distant Manchuria. TRADE.

Price.

The following extract is from the report of the Consul at Newchwang from which an extract has already been made :—

" At the time of the first shipments to Europe, the price of the beans laid down at Dairen was about £3 10*s*. per ton. By the spring of 1909 the value of the Soy bean as an article of commerce had become generally known, and a large number of British and other firms entering the field as prospective buyers, competitions gradually drove the price up. The new crop though well up to the average, proved not to be equal either in quality or quantity to that of 1908. The price of beans consequently rose still further and in February 1910, it reached £6 5*s*. per ton, the highest point it has touched as yet.

" At the price mentioned, China and Japan are practically out of the market as buyers and about 80 per cent. of the purchases of beans made since December last have been for the European market."

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CINCHONA.

CINCHONA in JAVA from 1872 to 1907, being extracts translated from the SCHEIKUNDIGE BIJDRAGEN TOT de KENNIS der JAVA-KINA, 1872 to 1907, by the late

K. W. van GORKOM,

arranged with an introduction by D. HOOPER.

INTRODUCTION.

INTRODUCTORY.

In 1908, the late Dr. K. W. van Gorkom published a pamphlet entitled Scheikundige Bijdragen tot de Kennis der Java-kina, 1872-1907. As the pamphlet contains matter of great interest, the Reporter on Economic Products to the Government of India had it translated into English with the consent of the author, and the work of editing the translation was entrusted to me. It has been decided to curtail and re-arrange the matter to make it more useful to Cinchona planters in India. It is of course almost up to date and supplements van Gorkom's "Hand-book of Cinchona Culture," translated by Mr. B. D. Jackson and published in 1883, and J. C. B. Moens' "De Kinacultuur in Azië, 1854-1882," both valuable histories of the introduction of the industry in the East Indies. Since they appeared, no books have appeared in English describing the wonderful progress made in Java in supplying the world with Cinchona bark and quinine.

A few words are necessary to explain the degree in which this Agricultural Ledger has been made to depart from the original.

INTRODUCTION.

Dr. van Gorkom's pamphlet is arranged chronologically with remarks made on the state of the plantations, describing experiments conducted from year to year. Many subjects are discussed, and so many experiments recorded one after another that it is not easy to follow such an arrangement with satisfaction. In 1888, for instance, the following subjects are dealt with—the composition of the bark of young trees compared with that of their parents; the temperature of drying bark; analyses of root-bark of Ledgers; composition of young Succirubras; influence of grafting. In other annual reports there are scattered references to the influence of different manures on the growth of the trees and composition of the bark. It is not convenient to traverse numerous unattached notes to discover the results of any one series of experiments: therefore the liberty has been taken of breaking up the text into chapters and grouping the paragraphs chronologically under particular subjects. This method will avoid the repetition of certain statements, and enable the reader to trace the results of the experiments to definite conclusions. It has also been found necessary to omit records of some inconclusive trials and a few controversial passages which do not concern English readers. Eighteen pages are devoted to a discussion on the manufacture in Java of quinium (a preparation of crude alkaloids); this subject as well as the remarks on quinetum have been disposed of in a few sentences. Unfortunately Dr. van Gorkom's death prevented any reference to him after the re-arrangement had been decided on.

It may be of interest to give some biographical notes on the career of Dr. van Gorkom and the other Dutch quinologists, mentioned in the following paper, who have done so much for Cinchona in Java.

Dr. Van Gorkom's connection with Cinchona.

Dr. Karol Wessel van Gorkom was born at Zutphen on the 22nd August 1835. He was trained under Professor Mulder at Utrecht, and in July 1855 he was appointed Military pharmacist in the army in the Dutch East Indies. On arrving in Java he was posted to the Military Hospital in Batavia, and in 1857 he became assistant in the Agricultural Chemical Laboratory at Buitenzorg. It was not until 1864 that van Gorkom took charge of the Government Cinchona Plantations, owing to the death of Dr. Junghuhn, and a better appointment, as the results show, could not have been made. The state of the gardens at the time Dr. van Gorkom thus described: "The Cinchona plantations were scattered at that time in the shaded forests and of little importance; and ten years of labour on

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them had led to but little result of practical value. Residents in the Indies laughed at the Government for attempting the cultivation, ridiculing it as an expensive hobby, and remarking that no good results could be seen after so many years. Cinchona growing was said to be a hobby of the two succeeding Governors (Pahud and Sloet van de Beele); and private people could not be induced to embark on it even experimentally.

"Meanwhile at home in Holland, the Colonial Secretary was continually addressed about the real or imaginary disappointments and the slowness with which the young enterprise was developing, in comparison with the one started in British India.

"The hopes that had attended the commencement of the culture in Java were gone, and the public had turned against the enterprise. The criticism in the daily papers went so far that the Governor General Sloet van de Beele was obliged to ask Junghuhn and Teysman to put an end to the discussion.

"Under these circumstances," continues van Gorkom, "I began the management of the cultivation, and endeavoured to adopt such measures and regulations as would lead to a reasonable development of the plantations. My exertions were made lighter by experience, in so far as we had learned at least not to follow in the footsteps of Junghuhn."

"In British India, where the alleged success in acclimatising Cinchona had been pointed out as an example, methods quite opposed to those of Junghuhn had been taken, and I accordingly thought it best to take the middle way and work gradually to the best system."

Van Gorkom thanks those who helped him at this juncture saying, that among the highly respected members of the Koninglijke Academie there were always men of recognised authority such as Professors Mulder, Miquel and Oudemans, who loyally stood by him with advice. Never was an opportunity neglected of guarding against a one-sided course of action, and for this reason instructive correspondence was commenced and kept up with foreign authorities, such as Drs. Jobst, Zimmer, Kerner, Souberain, Howard, Hasskarl, and the heads of the Cinchona Departments of Madras, Bengal and Ceylon on quinological matters. In the Indies Messrs. Teysman, Scheffer and Bernelot Moens supported the undertaking with their practical and scientific knowledge, and Dr. de Vrij, though at first he could not agree with van Gorkom's policy, after-

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wards changed his opinion and loyally gave his support and friendship.

Van Gorkom set as his first and foremost aim the increase of his stock of Cinchona trees, because, as he says, without trees there could be no product and no profit, nor an opportunity of judging the practical value of the undertaking. The history of the culture for years had shown that the stock at his taking over might have been greater, for those species which had been reared were the best, but the uninterrupted development of the plantation was hindered on account of the disease known as **Helopeltis.** All observations had shown that, but for this pest, Cinchona plants would thrive just as well as any other plant in Java.

Since 1864 it was his aim to obtain fresh seeds and plants from America and to exchange with the British Indian gardens. Gradually rich species were thus obtained; from British India he received **C. officinalis** and **C. succirubra;** and at last from America in December 1865 came the seeds of the Cinchona which was afterwards known as Ledgeriana.

He continues:—"It was not until 1872 that we were so far advanced, owing to improvement both in material and in chemical analyses, as to restrict ourselves to the rearing of **C. Ledgeriana** and **C. officinalis** for producing bark for the manufacture of quinine, and to the rearing of **C. succirubra** for producing pharmaceutical bark. In the early years there was no time for experiments other than those directly bearing on the growth and multiplication of the trees: they were considered premature, and such as were carried out were not done with much enthusiasm."

The above indicates the spirit in which van Gorkom undertook the direction of the industry. Added to his scientific training, he had the merits of a planter and was a good administrator. The forced labour that had been used in the plantations till 1864 was replaced by free labour; the prophecy that this would ruin the culture was not fulfilled. Private Cinchona planters in the island were always sure of his disinterested advice and help. He states in his pamphlet that "the undertaking of the cultivation of Cinchona was not intended for speculative purposes, but that humanitarian motives led to the experiment." These high principles characterised his successful management and his subsequent writings. Van Gorkom remained in charge of the Cinchona plantations until March 1875. From 1875 to 1878 he was Chief Inspector of Cultures. He retired from Government service in 1880 after 22

years' residence in the East. In his retirement he wrote frequently on Indian economic subjects and took the utmost interest in the welfare of the Netherlands East Indies. He died at Baarn, Holland, on March 10th, 1910, aged 75 years. INTRODUCTION.

Johan Carel Bernelot Moens, frequently mentioned in this treatise, was born in 1837 at Kralingen. He was a fellow student of van Gorkom at Utrecht, and qualified as a Military apothecary in 1857. After serving in Java for about eight years he again became associated with van Gorkom in 1872 as chemical assistant, and succeeded him as Director of the Cinchona Plantations in 1875. For five months in 1879 he was absent from Java visiting the plantations of India and Ceylon. In his numerous chemical researches he contributed much towards the future successful development of Cinchona culture, and his book "De Kinacultuur in Azië" is an excellent work of reference for all those interested. His description and illustration of **Cinchona Ledgeriana** as a distinct species has been accepted by Dr. Trimen of Ceylon and other botanists. He left Java in March 1883, and Mr. van Romunde was appointed Director in his place. Moens with the assistance of Messrs. van der Sleen and Heckmeyer continued his analyses of Cinchona bark at Haarlem. He was not permitted to enjoy his retirement for long; he died on October 2nd, 1886, at the early age of 49. **Moens' connection with Cinchona.**

The present Director, Pieter van Leersum, was born in 1854 at Utrecht, and was appointed Military apothecary for the East Indies in 1877. He became Deputy Director of the Cinchona Plantations in July 1884, and succeeded Mr. van Romunde as Director when the latter retired in May 1892. Van Leersum has been most assiduous in conducting chemical examinations of Cinchona bark grown under different conditions, and the results have been published in his "Kinologische Studien" and the quarterly reports of the plantations. Van Gorkom said of him, "Van Leersum's love of order and cleanliness in the laboratory has become proverbial." But it is not only in chemistry that van Leersum has excelled. He has ably administered the Government Plantations for many years, and has judiciously advised on a working policy for private Cinchona plantations and the management of the local quinine factory in Bandong. **Mr. van Leersum's connection with Cinchona.**

The idea of cultivating Cinchona in Java is reckoned to have taken shape in 1854; but not until some years afterwards did chemical researches begin—researches which have marched so steadily with the development of the plantations. **Cinchona introduced into the East.**

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It was, in fact, only in 1870 that Cinchona culture in Java had become so far advanced as to supply material with success for the commencement of systematic chemical research. Proposals were made in that year to associate a chemist with the culture, and at the same time a scheme or working-plan was formed for the solution of the problems nearest to hand.

The appointment of the chemist took place in May 1872, and since then every annual report of the Government has contained an important paragraph headed "Scientific Researches." The pages which follow are based on these paragraphs often quoted verbatim, and in that case marked by inverted commas.

It is well as a preliminary to state what steps had been taken prior to 1872 by the nations of Europe to ensure a supply of quinine in the event of South American Republics allowing their forests to be so worked out or their very limited plantations so to fail, as to starve the market. In the first place came France: La Condamine first tried to establish one species in French Guiana, but failed: and tried too to send living plants to France but his vessel was lost at sea: next, at the instance of the botanist and traveller Weddell, the French Government wished to establish Cinchona in Algeria. Weddell had returned from South America with seeds of a Cinchona which were sown under the care of a M. Houllet in Paris, and germinated. Some of the young plants were sent in 1849 to Algeria to M. Hardy at Hammah; but they failed,—"Killed by the Sirocco" was the report. English and Dutch botanists were meanwhile urging on their Governments to attempt to introduce the trees into the East. The Dutch Government moved first, sending in 1852 Hasskarl to South America (under the name of Müller,—for secrecy was necessary, and a great amount of caution and courage), and Hasskarl first sent seed to Holland, and then himself was taken off at Callao by a Dutch war-ship with 21 cases of young plants (several hundreds), and brought to Batavia with his precious cargo at the end of December 1854.

The English Government moved in 1858 sending Mr. (now Sir) Clements Markham to Bolivia and South Peru where he organised a threefold expedition, one part under Mr. Pritchett, one part under Messrs. Spruce and Cross and the third under his own guidance. Sir Clements Markham had to get his cases of living plants down to the coast by stratagem. Cross went back and made a second expedition in 1861 and a third in 1868. In 1865 an Englishman, C. Ledger, was so fortunate as to get from an Indian a packet

of particularly valuable seed, which he sent to a brother at London; a part of it was sold privately to British India, and part to the Dutch Government—its value being altogether unsuspected by the sellers. Meanwhile from 1865 forward for a few years the Dutch Consul-General at La Paz—Schuhkraft—contrived to obtain and forward seeds to Holland, and in 1868, another Consul-General—Roldanus—at Caracas obtained other seed for Holland.

Mention has not been made of the botanist and traveller Karsten who travelled in Venezuela and New Granada (chiefly the latter) from 1844 to 1856. He introduced **Cinchona lancifolia** into European cultivation.

These above are the names of the men who at much risk, before the time when the present history begins, got for European medicine the supplies of seed whence sprung the plantations in the East.

In 1872, when this history opens Java possessed:—

(*i*) A stock of **Cinchona Calisaya** derived from a plant obtained from Paris out of Weddell's seed and sent to Java in 1851 where it arrived more than four months later in April 1852.

(*ii*) A stock of plants raised from the seed bought from Mr. Ledger in 1865—**Cinchona Ledgeriana.**

(*iii*) A stock of plants derived from Schuhkraft's sendings—**Cinchona Calisaya.**

(1) A stock of **Cinchona Calisaya** derived from a plant obtained from Paris out of Weddell's seed, and sent to Java in 1851 where it arrived after a voyage of more than four months in April 1852. It is here called **C. Calisaya javanica.**

(2) A stock of plants of the same species derived from Hasskarl's mission, partly raised from seed in Java, and partly the progeny derived from seed sown in Holland, and shipped alive to Java in 1855. This also is called here **C. Calisaya javanica.**

(3) A stock of plants of the same species but of a slightly different variety, derived from seed sent by Schuhkraft, here called **C. Calisaya** of Schuhkraft.

INTRODUCTION.

(4) A stock of plants raised in Java from seed sent thither from Madras in 1866 by McIvor.

(5) A stock of plants of **Cinchona Ledgeriana** (at first thought to be **C. Calisaya)** raised from the seed bought from Mr. Ledger in 1865.

(6) **Cinchona Pahudiana** (at first called **C. ovata)** derived from Hasskarl's mission, and raised partly from seed in Java, and partly from seed grown in Leyden whereof the young plants were transported to Java by Junghuhn in 1855, and perhaps derived also from plants brought alive by Hasskarl. Its extensive cultivation had been abandoned in 1862.

(7) A stock of plants of **Cinchona officinalis** raised in Java from seed sent in 1865 from Madras, and sent also later from Bengal, Madras and Ceylon.

(8) A stock of plants of **Cinchona succirubra** received from Bengal in 1862 and from 1866 onwards from Bengal, Madras and Ceylon.

(9) Plants detected as mixed with **Cinchona Calisaya** from Hasskarl's mission and named **Cinchona Hasskarliana**—thought by some to be hybrids.

(10) **Cinchona micrantha,** raised from a plant received accidentally in 1862 from British India with **C. succirubra.**

(11) **Cinchona caloptera,** from plants derived from Hasskarl's mission, where they were mixed with **Cinchona ovata,** and also plants raised from seed sent from New Granada in 1870.

(12) **Cinchona lancifolia** from seed collected by Karsten in America and given by him in exchange to the Governor of Surinam for the Dutch Government, raised at Leyden and sent to Java in 1855 under the care of Junghuhn.

(13) **Cinchona pubescens,** one plant probably brought from Holland.

(14) Plants from Hasskarl's mission, called **Cinchona lanceolata,** and apparently a race of **C. ovata.**

INTRODUCTION.

Reports show that at the end of 1871 the following numbers of plants were in cultivation:—

1,009,000 **Cinchona Calisaya.**
164,000 **Cinchona succirubra.**
188,000 **Cinchona officinalis.**
16,000 **Cinchona lancifolia.**
1,050 **Cinchona micrantha.**

Moens' first duty to find relative values of the different species.

*At the end of May 1872 Mr. J. C. B. Moens was able to start his analytical investigations at Bandoeng. His first duty was to subject the different species of Cinchona, which had been brought into cultivation, to a comparative examination, in order to ascertain the kinds that might be considered best for multiplication. Of **C. Pahudiana** and **C. lanceolata** which had already been rejected, there was no need to take account. The main question was, therefore, to compare the values of **C. succirubra,** received from British India, and of **C. Calisaya,** which had been grown from seed successively provided by Dr. Weddell, Dr. Hasskarl, Schuhkraft, Ledger and the British Indian Government. These plants were distinguished by name as follows: **C. Calisaya javanica** to which belonged, besides the plants obtained from Hasskarl's expedition, the stock of the quinine plant reared first in Paris from seeds collected by Weddell in South America and presented to the horticultural garden at Leyden in 1851; **C. Calisaya** of Schuhkraft; **C. Calisaya anglica** and **C. Calisaya** of Ledger. These five sorts of Calisaya varied as much in appearance as they varied in origin, and even individual plants of each class showed on comparison remarkable variation, especially in form and colour of the leaf. The **C. Calisaya anglica** certainly diverged most by having larger leaves, and also on account of its quick and robust growth. Presumably it was a hybrid of **C. Calisaya** and **C. succirubra.** The original plants of the Calisaya species received before 1864 were called **C. Calisaya javanica.**

Work of Selection of Cinchona Calisaya of Ledger, afterwards distinguished as Cinchona Ledgeriana.

CINCHONA LEDGERIANA found particularly promising in 1872.

In 1872, among the Calisayas, the Ledger **(Cinchona Ledgeriana)** created special interest on account of the peculiar and surpris-

* The succeeding paragraphs are translated from the original Dutch. Following van Gorkom, whenever extracts are quoted from the annual reports inverted commas are used.

CINCHONA LEDGERIANA.

ing results of its analysis. "This species" (so says the report of 1872) "is not only worth attention on account of the high percentage of quinine in it, but also on account of the ease with which the quinine crystallises as sulphate, probably due to the small quantity of cinchonine and amorphous alkaloid present in the bark."

Eight analyses of the then about 6 years old Ledger plants gave as the extreme results:—4·16 and 8·15, with an average of 5·8 per cent. of quinine. One sample alone contained very little cinchonidine, while seven samples were free of this alkaloid. Two of those samples contained no quinidine; three only traces of it; and the three others 0·22, 1·27 and 2·38 per cent. of quinidine. The total amount of alkaloids ranged from 4·84 to 9·07 with an average of 7·48 per cent.

Quinidine thought to be connected with flowering.

The barks that yielded 1·27 and 2·38 per cent. of quinidine were taken from flowering and fruit-bearing trees (the first to do so) a fact which gave Moens occasion to believe in "a transformation of quinine into quinidine, through peculiar surroundings, which further researches might clear up." After this he remarks as follows: "Of how much importance the results of these experiments are for the cultivation is apparent. By replacing the uprooted trees with Ledger's **C. Calisaya** as is being done now, the quinine content of the plantation may be at least doubled."

Yields of the varieties of Calisaya inferior to Ledgeriana.

The richness of the Ledger bark astonished the trade and the manufacturers; and naturally it was resolved to grow no varieties of Calisaya but this only. The other varieties we may, without prejudice to science or practice, pass by without further mention except to remind the reader that the average percentages of the 8 samples of the **C. Calisaya javanica** showed—quinine 1·23, quinidine 1·24, cinchonine 1·53, and amorphous alkaloid 1·01, or a total of 5·01 per cent. of alkaloids: that of the 8 samples of **C. Calisaya** of Schuhkraft, the average percentage was—quinine 2·33, quinidine 0·43, cinchonine 0·79, amorphous alkaloid 1·34, or a total of 4·89 per cent. of alkaloids: that cinchonidine in both the **C. Calisaya javanica** and **C. Calisaya** of Schuhkraft existed in traces or was absent: and that two samples of the **C. Calisaya anglica** yielded respectively 4·38 and 6·04 per cent. of alkaloids made up thus:—0·42 and 1·30 quinine, 1·29 and 1·92 cinchonidine (indicating perhaps the influence of succirubra), 0·79 and 1·04 per cent. of cinchonine. And it must here be observed that although the Ledgers showed an unsuspected richness in quinine, these species here classed as inferior, **C. Calisaya, C. micrantha, C. Hasskarliana, C. officinalis,** etc., with their subsidiary alkaloids,

The yield of the inferior varieties.

could yield enough quinine to meet demands if they were cultivated on a large scale.

CINCHONA LEDGERIANA.

The care that the first consignment of Ledger seed required.

When the "Ledger" seed was received in Java six years before 1872, under the name of Calisaya seed, there was no reason to suspect its superiority, and moreover it was old and partly spoiled as was revealed on opening the hermetically sealed tin. Had not this seed been handled (fingered one might almost say) with the greatest care, scarcely a plant would have been obtained; as it was, only by individual attention some 20,000 plants were reared. After this when the seed became abundant, it was sown in nurseries as had been done before in Tjibodas in the years 1855-56, but with little success. If one has plenty of seed for disposal and does not need to be careful about the cost, glasshouses, etc., are not required; it is also certain that fresh seed from strong healthy trees, which are now acclimatised in the East Indies grow easier and better.

The 1873 and 1874 results confirmed those of 1872 on superiority of Ledgeriana.

In 1873, "the investigations of the various kinds of Cinchona were continued; they tended to confirm the results obtained in the preceding year. The "Ledger" bark kept up its high reputation, its quinidine and cinchonidine occurring in such a manner, as to be ascribed as characteristic of the tree, rather than due to influences of its surroundings."

In 1874, again "the investigation of the various species did not alter the favourable estimate of **C. Ledgeriana,** and the opinion on the other species. The market agreed also with this. There were, however, divergent results obtained in analyses of "Ledger" bark carried out by Jobst and Stoeder, which differences Moens ascribed partly to the nature of the samples examined and partly to the methods of chemical analysis."

He was of opinion that the quinine content of the Ledger bark (the trees were then about eight years old) was still on the increase.

Older bark contains most alkaloid.

"It had been discovered in 1872 that the bark of the younger parts of the trunk and branches (always) contained less alkaloids than that of the lower parts; the crop of 1874 was accordingly sorted into 1st and 2nd qualities, *i.e.*, older and younger parts. The crop consisted of $\frac{3}{4}$ first and $\frac{1}{4}$ second quality, which showed in average a considerable difference."

In 1875, "thirteen flowering samples of **C. Ledgeriana** from the original planting (1866-1867) showed (with the exception of one which contained 5·91) amounts of quinine sulphate from 9·96 to 14·42 per cent. Seven trees of the thirteen showed more than 11 per cent."

CINCHONA LEDGERIANA.

Ledger plant's flower and the bark is analysed.

Analysis of individual trees with a view to selection of seed parents.

Succirubra and Ledger behave differently in regard to renewed bark.

In 1876, "the analyses chiefly aimed at ascertaining the percentage of quinine in flowering and seed-producing Ledgers: 34 trees were examined for this purpose, and one of them contained 13·25 quinine equal to 17·83 per cent. of sulphate of quinine; two others showed 15·73 and 15·75 per cent.; all appeared rich; minimum—8·90 per cent. (To calculate the quantity of crystallised sulphate of quinine, the quantity of quinine is multiplied by 1·346). The Ledger plants had attained the age of 10 years in 1876."

"Although it was proved that the renewed bark of Succirubra, at least at first, is richer than the original bark, an experiment carried out on the Ledger bark showed that an increase in amount had not occurred—on the contrary there was a considerable decrease."

"It was remarked as a peculiarity that sulphate of quinine taken from the Ledger bark was less coloured and purer than that taken from the officinalis bark."

A very rich Ledger detected in 1877.

In 1877, "during the examination of the barks of 16 flowering Ledgers, one was found to contain 16·57 per cent. sulphate of quinine."

Variability noticed.

In 1878, "it was remarked that four-year old descendants of the mother trees showed a decided difference both in external appearance as well as in quality. Moens remarks that this observation is of much importance to planters, because it enables them on comparison of the young plants with the mother trees, to reject those which differ from the parent."

Inheritance seemed to be true.

In 1879, "during the investigation of the Ledger seedlings various important results were obtained:—1st, it appeared that the young trees inherited in alkaloids the character of the parent trees so that if for instance the parent tree contained quinidine, the seedlings also contained quinidine; 2nd, it was found that it was possible to select by external appearance the worst and most hybridised specimens, and when this was done, the analyses showed a percentage of quinine which justified the valuation made on sight. For this investigation the seedlings by eye were classed into four groups, and the analyses made confirmed the correctness of the classification. It was also found that the percentage for such young trees was satisfactory, and held out encouragement for the future. Trees of the same descent and appearance which had developed best, gave the most alkaloid."

Young trees of second generation most promising.

No effect of stock on graft in the matter of alkaloids.

In 1881, "the selection from the gardens of various types of the same species was continued, and the analytical results confirmed

the exactness of the selection. The fear that the harvest would suffer generally if the Ledger were grafted on to Succirubra was not justified by analytical investigations. At least in the one-year old shoots examined no cinchonidine was found as a result of the stocks."

CINCHONA LEDGERIANA.

"Eight analyses on now about 15-year old Ledger parent trees, which had been examined before, did not show an increase of alkaloid with age, some even showed a decrease in quinine. One individual, which in 1873 only showed traces of cinchonidine, now contained 3·45 per cent. It was noted that a decrease in alkaloid may be due sometimes to an excessive formation of scales (rhytidoma-formation), which contain much less alkaloid than the living bark. As the scales are powdered along with the bark for the purpose of investigation, they naturally lower the percentage. It may, however, be accepted that, generally speaking, the Ledger bark is mature in the 7th or 8th year, and does not increase in quinine after that period."*

Trees 15 years old were recognised as past the best.

Ledger bark is generally mature in 7th or 8th year.

"The 2-year old Ledger bark, regenerated after shaving, was not so good as the original bark, and its quinine sulphate crystallized with difficulty on account of the great amount of colouring matter. It was, therefore, decided in future to allow the bark to grow another year before rescraping it."

Value of renewed bark.

1884. From the appointment of van Leersum as Deputy Director in July "until the end of 1884, analyses were restricted to the examination of trees intended for artificial multiplication, and in this the plantation which supplied the best material were those from seeds of the mother trees Nos. 23 and 38."

"It was a remarkable fact among the fairly promising progeny of No. 23, that as many as 9 out of 13 contained cinchonidine, an alkaloid which occurs less frequent in the Ledger seedlings, from No. 38 (out of 14 individuals only four contained it) and was absent from both of the parent trees. This again is assuredly a remarkable phenomenon which should not be lost sight of."

Cinchonidine appeared in descendants of two parents which were without it, particularly in one lot of descendants.

In 1885, "the culture analyses carried out had for their object in the first place the detection, or one should rather say the getting on to the track, of the richest descendants reared from the seed of the richest parent trees, with the intention of using these descendants for artificial multiplication and of creating seed-plantations from them. It was remarkable that the bark of all these descendants, although some were distinguished by a very high quinine

Selection continued.

*For the maturity limit see "De Indische Mercuur" of October 15th, 1907.

CINCHONA LEDGERIANA.

percentage, showed cinchonidine in a greater or lesser degree, traces of cinchonidine had been found in the bark of the parent tree."

"In consequence of its presence these descendants were not used for making graft plantations for seed-collecting."

Quinine may increase even after tenth year.

New analyses of Nos. 73 and 23 proved that even after the age of 8 or 10, say at the age of 14, the percentage of quinine can increase; this indicates that care should be taken in fixing the so-called "maturity limit."

The report for 1888 records that the selection of Ledger descendants best suited for propagation by grafts had been continued. In 1887 a specimen was found with 13 per cent. quinine: in 1888 the 10-year old descendants of parent tree No. 23 were examined and were found to contain 10·31, 12·36 and 10·51 quinine: in two descendants of No. 38 there was found 12·30 and 9·80 per cent. quinine. As a result of these analyses "this last but one (the report says) is found fit for artificial multiplication, as the bark

Selection continued.

appeared to contain 12·36 per cent. quinine without cinchonidine and quinidine." This was on account of the absence of the two allied alkaloids. In three out of the five cinchonidine was found but not one showed any quinidine. The reader should bear in mind the analyses discussed before, which caused a surprise by indicating the presence of cinchonidine in descendants of parent trees in which that alkaloid was not found; and it is to be remarked that the growth and stamina of the trees were not spoken of.

In 1889, "ten $2\frac{1}{2}$-year old descendants raised from seed of parent trees 23—73, 89, chosen from very closed plantations and mixed, gave 9·51 quinine, 0·64 cinchonidine, total 10·90 per cent. of alkaloids. The high percentage, so says the report, shows convincingly that it is not necessary to look for success exclusively (whoever stated this?) from the artificial rearing of Ledgerianas."

Analyses of grafts for changes with age.

In 1892, "ten alkaloid determinations were carried out on barks of different grafts with a view to determine whether the alkaloid increases or decreases with age. Four samples confirmed again that the increase in the alkaloid percentages is greatest in the second (*sic*) year."

In 1895, "analyses carried out to ascertain if the alkaloid percentage increases with the age of the tree, show, that up to the fourth year—*i.e.*, as far as the researches had gone in 1895—no important decrease of quinine, in sound trees, is noticeable: although it would appear from these investigations that the quinine had decreased $\frac{1}{2}$—1 per cent. in the past year, that decrease was due

not to age, but to bad soil, as is sufficiently proved by 5 analyses of grafts of the same nature and of the same age but standing on good ground."

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In 1896, "36 analyses concern the increase or decrease of the alkaloid percentage by age. They show that after the fourth year till the eighth or tenth year—that is so far as the experiments had gone—the alkaloidal content of **C. Ledgeriana** and the hybrid of **C. Ledgeriana** and **C. succirubra** remains fairly stationary with only such slight deviations, as may be ascribed chiefly to disease or to unfavourable nature of the soil."

The alkaloids in the bark change little between the fourth and the tenth year.

In the same year, "seven analyses were made of samples of bark from the Ledger parent trees at Tjibeureum and Tjinjiroean, now about 30 years old. Though the average quinine percentage (5·78) shows a higher figure than before, an increase of alkaloid is not to be assumed, for this is exclusively the consequence of the greater quantity of bark, which in these critical times for the Cinchona cultivation is left behind in the gardens as valueless. It may be noted that notwithstanding the great age of these trees the alkaloidal content appears pretty constant.

In 1898, "38 analyses showed again that a steady decrease, though slight, of quinine takes place after the fourth year, and a graphic chart (published in the report) demonstrates clearly that to the fourth year there is a steady rise, then to the 9th year there is a regular decrease."

In 1899, "concerning the question of the increase or otherwise of the percentage with the age, 78 analyses were made and the results have been set out graphically in the report." From the chart it would appear that the increase takes place almost up to the fifth year, after which a gradual decrease follows, causing the height of the third to be reached again at the end of the eleventh year.

Increase up to the fifth year, thence slow decrease, so that bark 11 years old is no better than that 3 years old.

"These investigations moreover taught that the percentage both of the manured and unmanured trees had enormously decreased."

In 1900, **"eight analyses afresh demonstrated a steady decrease in quinine after the fourth year, although very slight."**

"Four samples from the crop of now about 33-year old Ledger parent-trees showed respectively 7·10, 7·00, 5·48, and 5·41 per cent. of sulphate of quinine in trunk bark, renewed bark, branch and root bark."

In 1901, "a series of analyses—294-315—is a continuation of the experiments started 13 years ago in regard to the increase or

Further analyses confirm

CINCHONA LEDGERIANA.

decrease of percentage by age. The chart shows that an increase goes on almost till the fifth year and then gradually goes down." It would have been desirable to find out by control experiments if by manuring and deep tilling this decrease could be arrested.

optimum of bark to be at fifth year.

Can tillage arrest subsequent decrease?

"Analyses 348-351 are of one and two-year old grafts, Lt. B. and Lt. G., from a plantation at Nagrak. They are quick-growing Ledgerianas as is evident from the fact that they yield a harvest in the third year." Lt. B. in its first year held 3·40, and in its second year 6·30 per cent. of quinine. Lt. G. in its first year held 4·03, and in its second year 6·85 per cent. These are good figures for trees so young, and hence they are called quick-growers. But as they have to yield a product also in the third year, they must have been closely planted: and consequently they will need to be thinned, when a good many trees of this kind will be necessary to give 1 kilo. of dry bark."

"Two young broad-leaved Ledger-seedlings, called W^2 and W^3, at Tjibietoeng and Tjibeureum gave respectively 14·60 and 13·05 sulphate of quinine and 0·89 and 0·81 cinchonidine." The age of these two very rich trees is not stated.

More figures showing decrease with age.

In the report for 1903, "25 analyses show in a graphic chart a decrease with the greater age. In the year under report the decrease was from 8·50 to 8·20 per cent. The average of these figures at the end of the fifteenth year was found to be about the same as that of the eighth year. In the foregoing charts there shows an increase until about the fifth year, after which there is a gradual decrease."

"Analyses 115-118 of the parent trees 38*f* and 38*a* at Rioengoenoeng are remarkable. The barks examined in 1882 by Moens contained 12·60 and 12·05 quinine sulphate, and now 21 years later only 6·82 and 5·80."

"From these trees cuttings (says the report of 1903) will be taken with the object of founding a small trial plantation in order to discover if the grafts at a younger age again contain about 13 per cent. of quinine sulphate like the plantations originally created from it."

In 1904, "21 analyses concern the continuation of the experiment regarding the increase or decrease with age. In the year reported on the average percentage showed some increase, evidently for the same reasons through which the Ledgeriana crop was this year $\frac{1}{4}$ per cent. higher than last year." In 1903 the percentage of the Ledgeriana crop decreased $\frac{1}{4}$ per cent. especially in the

hybrid gardens on account of the abundant flowering due to the strong drought; but in 1904 it amounted to about the same as in 1902. In the report, paragraph 4, "Crop of cinchona," attention is directed to the need of regarding this as a factor which has to be taken into consideration, like so many others, in judging the increase or decrease with age. CINCHONA LEDGERIANA.

In the issue of "De Indische Mercuur" of the 15th October 1907, we referred to Dr. Hunger's ideas on the so-called age-limit of the cinchona tree. Hunger relied on the graphic chart, illustrating the experience of 15 years, which was given by van Leersum in his annual report for 1904. According to this chart, the limit of increase of alkaloid is in the fifth year, after that a gradual decrease takes place amounting to about $1\frac{1}{2}$ in the tenth year and $2\frac{1}{2}$ per cent. in the fifteenth year. In concluding some analytical results, van Leersum noted **that a Cinchona tree of four years old had not reached its maximum limit of quinine, but that the comparative increase after the fourth year is not very large.**

Cinchona succirubra.

Seeds of **Cinchona succirubra** were received in 1862 from British India.

Analyses made of the bark in 1872 gave the following results: — CHINCHONA SUCCIRUBRA.

	Total alkaloid.	Quinine.	Cinchonidine.	Cinchonine.	Amorphous alkaloid.
	7·94	0·75	3·80	2·04	1·35 (9-year old trees).
	7·93 & 8·48	0·74 & 1·80	3·32 & 4·66	2·85 & 1·16	1·02 and 0·86 (7-year old trees.)
	12·64	1·39	8·53	1·65	1·07 (5-year old trees).
Four year old trees divided into six parts.	9·47	1·60	4·70	2·10	1·07 lowest part of trunk 0·44 kg.
	7·23	0·85	2·35	2·94	1·09 above the lowest part 0·33 kg.
	7·55	0·76	2·95	2·74	1·10—0·28
	7·01	0·83	3·09	2·07	10·02—0·23 kg.
	6·38	0·58	2·38	2·58	0·84—0·11
	5·95	0·58	1·87	2·60	0·84—0·05
	4·49	0·39	1·48	1·59	1·03 } Big branches
	3·83	1·22	1·39	1·08	1·08 } 0·24 kg.

"From these investigations" (so says Moens) "it appears that **Cinchona succirubra** reared in Java, though containing much alkaloid, is inferior in quinine content to the Calisayas, notably to Found inferior to Ledgeriana.

CINCHONA SUCCIRUBRA.

Cinchona Ledgeriana, and moreover the large amount of cinchonidine hinders much the separation of the quinine as sulphate."

Maturity of bark.

Broughton's* observations are confirmed—that after a certain age the percentage of alkaloid does not increase. Healthy and strong specimens (the oldest trees) certainly yield no more alkaloid than the younger ones (9 and 7 years old as compared with 5 and 4 years old. Moens also draws attention to the importance of the experiment with different parts of one trunk of the six last but two numbers in the table above and of the big branches of the two last. Even in the youngest parts of the trees, the nature of the alkaloids is the same and relatively the same amount of cinchonidine is found in them as in the oldest parts. The bark of the branches resembles the bark of the youngest parts of the stem.

Nature of alkaloids the same in trunk and branch.

In 1881, "fresh experiments confirmed Moens' former opinion that the increase of the quinine and the decrease of the cinchonine in renewed succirubra bark is not due to the covering of the tree but to the restoring process itself, a fact also shown in **C. officinalis."**

A difference detected between Indian bark and Java bark of the same stock.

Moens had brought from British India some succirubra bark, to compare it by analysis with that of specimens reared in Java, and originally from British India. He found in the Indian grown bark less cinchonidine and more cinchonine, which explains the difference in composition of the quinetum manufactured in Java and that manufactured in British India. In other respects the species cultivated in the two places were the same. It should be remembered, that De Vrij complained of the succirubras of Java appearing to have lost much of their original character.

Renewed bark differed from original bark.

In 1885, particular importance was attached to "an analysis of regrown bark 4-year old of five trees taken together. Five years after the application of the mossing process and 3 years after the covering put on to protect the exposed trunk had been removed, the bark did not show a return to the original composition of the succirubra bark, but a great amount of quinine (4·36 per cent.) was found in the renewed bark, this being more than if it had been collected after the fixed age of 3 years. The total alkaloid showed 9·92 per cent.; the cinchonidine percentage was 1·05."

The report of 1887 says that "from the investigation of the renewed succirubra bark, 6 years after the practising of McIvor's†

* John Broughton, B.Sc., Quinologist of the Madras Cinchona Plantations from 1866 to 1874.

† William Graham McIvor, Superintendent of the Madras Plantations from their commencement in 1861 to his death in 1876.

process, it appears that this bark still retains its composition and does not yet show a return to the original composition of succirubra bark." CINCHONA SUCCIRUBRA.

In 1889, "two analyses were carried out to investigate if the material of young succirubras, which had to be removed for the purpose of thinning, would supply even a small product that could be exploited with profit. The question was answered in the negative. Chips of the outside layer of 50 young trees held 1·10 per cent. of quinine or a total of 5·89, and the chips of the remainder of the bast up to the wood of 50 trees 0·92 per cent. of quinine or a total of 5·33. With the result as far as possible the young plants, instead of their bark being harvested, were replanted on land which was cleared." Very young trees contain very little quinine.

Cinchona officinalis.

The seed of this species, yielding the crown bark of commerce, was first sent to Java in 1865 by the Government of British India. CINCHONA OFFICINALIS.

Analysed in 1872, the bark had the following composition:—

Quinine	1·75
Cinchonidine	·78
Quinidine	·16
Cinchonine	·37
Amorphous alkaloids	1·30
	4·36

The analysis shows that both in quality and quantity the alkaloids corresponded with what had been obtained in British India. This species had already been split up into many varieties, of which were recognised: **vera, crispa, chahuarguera** and **angustifolia,** and these were to be subjected to further investigation as was justified by the detection among them in the course of reports published later of individual plants possessing a high percentage of quinine. Varieties. Detection of promising trees.

In 1873, among plants of **C. officinalis** more individuals were found that appeared to be of great value for the manufacture of quinine, and they were also recommended for their quick growth.

In 1874, it was reported that a large amount of quinine was found in the 5-year old plants of **C. officinalis** at Nagrak.

In 1875, "the analyses of the renewed bark of this species appeared to be in opposition to the results obtained previously; the new bark contained 4·72 per cent. of sulphate of quinine, whereas the original bark showed 6·74 per cent." Renewed bark relatively poor.

CINCHONA OFFICINALIS.

In 1891, thirty analyses were made in order to select the richest officinalis trees in Kawah-Tjiwidei that were fit to be grafted in succirubra plantations. "The investigation had again shown the considerable variation in the composition of the bark among typical specimens of this species. The high quinine content found in the bark of many species was striking (the average percentage of the 30 trees shows 6·2; the extreme figures are 0·45 and 10·60). Of 30 trees that were examined, 9 showed a higher percentage of quinine than the maximum figure (7·52) which Moens gave in his standard work. Two specimens showed even 10·60 and 10·28 per cent. quinine."

Individual variation striking.

The 1872 discovery regarding Ledgeriana stopped improvement work on officinalis, but not its cultivation.

"The improvement by cross-breeding with the **C. officinalis** had in the previous year not been attended to. The discovery of the high percentage in the bark of Ledgeriana required all (?) attention, and the extension of the **C. officinalis** was not considered important." After that however the rearing of **C. officinalis** was not neglected—witness the following numbers which show how many **C. officinalis** plants stood in the ground at the close of each year:—In 1872 the number amounted to 195,476, and at the end of the years 1875 and 1878 it had reached respectively 491,052 and 535,171. At the end of 1883 the number of **C. officinalis** had diminished to 475,000, in 1885 to 276,000, and in 1891 to 47,900.

"In our estimation (says van Gorkom) the value of **officinalis** as a plant for cultivation has always been high, although it must be acknowledged that this species compares unfavourably with others in respect of robustness, but on the other hand its smaller requirement in the matter of growing space is in its favour (4 × 4 feet as against 6 × 6 for **Ledgeriana** and 7 × 7 for **succirubra**).

There seemed to develop an undue bias against C. officinalis.

In 1892, "the search for a high proportion of quinine in **C. officinalis** was continued and although the percentage of two trees might be called rather high, 7·77 and 7·80 respectively, it appears (says the report of 1892) from the 22 analyses made, that they cannot be recommended for further artificial cultivation. It is not clear to me, comments van Gorkom, on what basis this statement is founded, seeing what was noted in the previous year about **C. officinalis.** The average percentages of quinine, cinchonidine and total alkaloid, of the 22 trees which were examined, were found to be 5·10, 2·31 and 7·83 respectively. The lowest quinine percentage in one tree was 1·85, along with 3·40 cinchonidine and 6·40 total alkaloid."

"If these figures are compared with the average composition of succirubra barks, they do not appear to be so bad, and if **C. officinalis** is not fit for being 'factory' bark, it is still not to be despised for pharmaceutical purposes. It might be reiterated here that among all the Cinchonas there is none which supplies a bark so typical, characteristic and easily distinguishable as the **C. officinalis** which furnished the invariably appreciated 'Loxa' bark. In fact among Cinchonas cultivated on a large scale, there is none which has comparatively so small a production on account of its slender trunk and branches as that species. It is at the same time also one of the prettiest Cinchona trees on account of its dark green foliage. For my part I always regret that the **C. officinalis** from about 1883 has been judged and treated so very badly."

CINCHONA OFFICINALIS.

Its characteristics.

We now come to the refutation in 1893 of a supposition put forward in 1891 to the effect that the shade which plants of **C. officinalis** got from plants of **C. succirubra,** among which they were growing, had raised the content of its bark. This is what had been said in the report for the year 1891. "There is nothing left but to ascribe these high figures (9 trees in 30 had more than 7·52 per cent. of quinine, 2 of them even 10·60 and 10·28) to the cultivation, to the close planting and dense growth, and to a proper conservation of the gardens. The suspicion mentioned in the report of 1890 that the improvement of the product of the **C. officinalis** was in consequence of the interplanting with **C. succirubra,** which caused a denser plantation, has been confirmed by analysis.

Attempts to find cause of variability.

"This report of 1893, however, says that a continuation of the experiments, proves the supposition unfounded, since out of a series of analyses of 50 trees, only one specimen showed 7·79 per cent. of quinine, whilst all the others were far below that. (Nevertheless the comparative table in the report of 1894 shows the result of three analyses of **C. officinalis** as giving 9·83, 9·65 and 8·54 per cent. of quinine).

"These investigations," says the report of 1893, "will be continued, for doubtless there may exist specimens of **officinalis** bark having a high quinine percentage as has been the case with Ledger bark—witness the 10 per cent. barks that were obtained in 1891, which were then ascribed to an improved method of cultivation" (*viz.*, the interplanting of succirubras, to secure a denser shade).

"Several investigations will be necessary for this purpose because up to the present, as is the case with **Ledgeriana,** not one

CINCHONA OFFICINALIS.

external botanical character has been discovered to indicate that the bark contains a high amount of quinine."

"It may be useful to insert here what Moens thought about this species. In his report of 1872 he said "as regards the analyses of **C. officinalis** and **C. micrantha,** it can be seen that the alkaloid percentage corresponds, both in nature and in quantity, with what had been ascertained in British India. **C. officinalis** includes many varieties, which will be subjected to further investigation."

"In his report of 1873 he stated that **C. officinalis** is recognised by the distinctness of its varieties, and that in British India the small leaved variety had been principally reared. This species in average quinine content more or less corresponds with the **C. Ledgeriana.** The variety of **C. officinalis** which grows in British India seems to be scarce among the cultivated plants of that species in Java. One plant (No. 84 with 7·52 per cent. of quinine) occurred which could be reckoned to belong to this variety, but its bark does not particularly distinguish it from the other varieties cultivated here: along with the Ledgeriana the officinalis is the most promising plant for cultivation, as it has rather a high average quinine content and grows everywhere readily and luxuriantly."

In 1894, "60 analyses of officinalis trees again confirmed the opinion that the unusually high figures for quinine sometimes occurring in certain trees of **C. officinalis** are due to individual differences and not to the method of cultivation. Only one specimen, with 9·83 per cent. of quinine, was found fit for propagation."

Some eye-characters found to indicate excellence.

In the report for 1899 it is stated "that not one botanical character is known, which in this species indicates a large amount of quinine in the bark, as is the case with **C. Ledgeriana.** But repeated examinations justify the conclusion that the broad-leaved varieties of officinalis are better than the narrow-leaved, and the colour of the nerves of the leaf seems also to give some indication."

It should be remembered that in British India the narrow-leaved **C. officinalis (var. angustifolia)** was shown to be the richest variety. It was found in Java to contain much quinine, but the seedlings exhibited for the greater part large leaves; and therefore the vegetative method of reproduction was adopted for the variety.

Cinchona Pitayensis.

CINCHONA PITAYENSIS useless.

In the report of 1892, "ten analyses indicate the composition of all the plants of this species which occur in the experimental garden at Tjinjiroean, and one analysis—No. 64, gives the per-

centage of one hundred and fifty 3-year old grafts that had been reared from this species." The quinine was 2·31 and total alkaloids 4·85 per cent. CINCHONA PITAYENSIS.

"The 10 parent trees contained from 2·71 to 6·75 quinine, 0·80—2·90 cinchonidine and 5·10—9·70 total alkaloid.

"It appears from these analyses that none of these kinds can be recommended for further cultivation on account of the low percentage of quinine, and on the analyses of the 3-year old grafts, their propagation which commenced in 1888 has been abolished."

In 1896, "two analyses were made of the 8-year old grafts of **C. Pitayensis** at Tjinjirocan. In the report for 1892, it had been remarked that this species is not fit for further cultivation on account of its small content of quinine. The results now obtained confirm the justice of these conclusions. The material for analysis was supplied by 100 grafts, both from the broad and narrow leaved trees. The results were 0·96 from the broad and 1·09 from the narrow leaf in 3·41 and 3·56 per cent. of total alkaloid, respectively."

"Further for the cultivation of pharmaceutical bark the species appeared to be quite unsuitable, first on account of its slow growth and the formation of very short articulations, and secondly on account of its peculiarity of forming an extraordinary number of thin branches, even more than **C. officinalis,** which makes it impossible to obtain the bark in regular quills."

Cinchona micrantha.

This species of Cinchona, yielding "Grey bark", was received in 1862 with the succirubras from British India. Examination showed it to contain:— CINCHONA MICRANTHA useless.

Quinine	traces and none.	
Cinchonidine	0·8 and 0·1	
Quinidine	.....	
Cinchonine	6·8 and 5·66	
Amorphous alkaloids	0·87	0·54
Total	8·37	7·30

Cinchona Hasskarliana.

This species was named by Miquel from specimens collected in Hasskarl's expedition. There are two varieties, one with long and CINCHONA HASSKARLIANA.

CINCHONA HASSKARLIANA.

the other with short fruits. The composition of the bark was found in 1872 to be:—

Quinine	1·55	and	1·14
Cinchonidine	·71	„	·52
Quinidine	·12	„	·39
Cinchonine	·90	„	1·71
Amorphous alkaloids	1·45	„	·43
TOTAL	4·73	„	4·19

In 1875, "three Hasskarlianas, tall and slender trees, which had been placed in 1862 in the forest above Tjinjiroean, did not show any difference in the amount of alkaloid, compared with trees that stood in quite open land. These Hasskarlianas, recorded as Calisayas, had been brought under more favourable conditions in 1864, by carefully thinning the surrounding forest. The bark was good, but thin, as is always the case when Cinchonas stand in the shade of high forest trees."

Cinchona Calisaya.

CINCHONA CALISAYA.

In 1892, analyses were made of trees which had been reared from seeds received in 1882 of the following species:—Finest Calisaya of Mopiri, Calisaya of Inquisive, Zamba Morada, Duras Milo and Cocola. The highest quinine figures were 2·9 to 4·5 per cent.

Ledger Hybrid.

LEDGER HYBRID.

1882. "Among the plants of **C. Ledgeriana** reared from seed specimens were found which approached **C. succirubra** in their ready growth and large broad leaves. They were probably hybrids of the two species. Fourteen of them were examined and they gave from 2·08 to 11·10 per cent. of quinine. The cultivation of the richest specimens should prove very profitable, says the report, if they truly preserve the type. They grow easier and quicker than Ledgeriana, and produce more bark in a given time." A few seeds were sown in order to make further investigations.

Promising analyses.

In 1885, "another considerable series of analyses of these plants —distinct in habit, in flower and in leaf, from **C. Ledgeriana**— gave surprising results. They generally distinguished themselves by giving a high percentage of total alkaloids. In some of these hybrids not only was the average amount of quinine equal to the average amount in typical Ledgers, but the quantity of cinchonidine surpassed even that of the succirubra."

LEDGER HYBRID.

In 1890, "the great interest taken by private Cinchona planters in the rearing of Ledger and succirubra hybrids led to a series of investigations of this tree. This interest is due to the fact that the Ledgeriana in many localities apparently will not thrive, and to the desire to collect in the shortest possible time the greatest possible crop."

Conclusions from the 1890 analyses

"The first object in analysing the bark of hybrids was to find trees of high quinine content suitable for artificial reproduction. The investigation of 12-year old trees was instructive in more ways than one, but it created disappointment."

"In the first place, it appears that hybrids have not any distinguishing external character which indicates that the bark contains a large amount of quinine."

"Secondly, it is proved that among the hybrids a tree which is really fit for propagation is an exception."

"Of the 40 analyses carried out, one (No. 19) gave a good result. No. 31 was from a tree which had been examined before."*

"Thirdly, it has been sufficiently proved that the quinine content decreases with age. The proofs of this are:—

1st.—That the average quinine content of the barks from the same gardens which supplied the trees for analysis was much higher in 1885 than at present.

2nd.—That one tree under analysis, No. 31, showed 10·67 per cent. of quinine in 1885 and now (1890) 8·47 per cent.

3rd.—That the tree No. 29, the bark of which was examined (9·26 per cent. quinine in 10·90 total and only traces of cinchonidine with 0·19 quinidine) is one of the least developed and youngest in the plantation."

"If these facts justify conclusions, then it would seem—

Artificial propagation and harvesting rather young promise best return.

(*a*) that the artificial multiplication of hybrids is much more preferable to that from seeds.

(*b*) that cutting the hybrids at fixed periods with a view to obtaining young coppice shoots or the digging up of plantations after a few years is to be recommended."

"Further investigations must be made before it can be decided at what age the digging out or coppicing should take place.

*Van Gorkom thinks that there is a mistake here regarding No. 19, for he inserts the following note. No. 33 contained 0·33 quinine, 0·66 cinchonidine, 0·35 quinidine, total 4·10 alkaloid. No. 19 showed 4·81 quinine, 1·81 cinchonidine, no quinidine and 8·50 total. In the 40 analyses, not counting Nos. 19 and 33, the figures for quinine range from 0·95—9·26 and those of the total from 4·71—12·01. These figures do not justify the statement that No. 19 gave a good result.

LEDGER HYBRID.

"Another object for investigating the barks of hybrids was to promote seed plantations from them."

Renewed investigations on the hybrid and fresh cultivation.

In 1897, "two analyses were made of the seedling hybrids of **C. Ledgeriana** and **C. succirubra** discovered recently on the Tjibietoeng estate. Both trees, estimated to be about 20 years old, are beautiful specimens of typical hybrids, having a circumference of 62 and 69 c. m. (24 and 27 inches) at the height of a man's chest, and such trees are very scarce, not only having a high quinine percentage (10·60 and 11·70), but containing comparatively little cinchonidine, which has probably been formed by age."

"At Tirtasari, small plantations of the hybrid had already been started, and four trees with a trunk circumference of 75, 52, 62 and 69 c. m. (29·5, 20, 24 and 27 inches) respectively showed 7·44, 7·80, 12·78 and 14·13 per cent. of sulphate of quinine."

Although not stated, it should be understood that this plantation is the progeny of the two trees and that they were already old as they had almost the same circumference of stem just mentioned.

In 1898, "in connection with experiments in the effect of light upon the distribution of the alkaloid in the bark which in the former year was made on **C. Ledgeriana,** the hybrid was now examined (Nos. 23^3 were used for the experiment)."

"The same method was followed. The trunk bark of two trees, several metres high, was cut into pieces of 25 c. m. long which were examined separately. A graphic chart shows that there is a more even distribution of the alkaloids in these hybrids than in the Ledgers, without any deviation at different heights. The great influence of the chemical and physical character of the soil on the yield of alkaloids made itself again conspicuous; the grafts of the above mentioned hybrids which were examined were of the same age and were planted at equal distances from each other, but they showed enormous differences."

The distribution of alkaloids in the hybrid.

Variability of the hybrid.

Cinchona robusta.

CINCHONA ROBUSTA.

In 1891, "the proposal to propagate artificially **Cinchona robusta** (a hybrid of **C. officinalis** × **C. succirubra**) was disposed of in the negative by the results of ten analyses.

Considered unpromising in 1891.

"The extremes in quinine, cinchonidine and total alkaloid found in 10 trees were respectively 1·44—4·15, 2·52—7 and 7—11·30; the averages were respectively 2·915, 4·835 and 9·925 per cent. These trees were taken from amongst the ten-year old ones which stood on the most elevated plantation at Kawah-Tjiwidei and were pro-

bably some of the 70 trees imported by Moens in 1881 from British India. CINCHONA ROBUSTA.

In the report of 1901, "61 analyses concern the examination of the **C. robusta.**" Quinine present in too small percentages.

"This is what Moens says in his treatise "De Kinacultuur in Azië," on the subject of **C. robusta**:—The leaf is between that of succirubra and officinalis; it resembles the latter more in the pointed apex, but is closer to the former by the absence of scrobiculæ. The blossom resembles in colour that of officinalis, but it is a little lighter. The fruit closely resembles that of succirubra, but when fresh, is very similar to the fruit of officinalis. The hairiness is not enough to justify the name of **lanosa,** there is not much more of it than with some forms of succirubra. The alkaloid content is also between those of the two species. There is no feature, therefore, to oppose the recognition of this plant as a hybrid." Reasons for regarding C. robusta as a hybrid.

"Moens, however, in opposition to what he had said about this variety, adds on page 257 of his work, that in Ceylon this Cinchona is reported to contain from 3 to 6·7 per cent. of quinine, but the exact determination of the plants which gave such a high quinine content is doubtful. In the Java officinalis plantations strong growing succirubra-like plants also occur, and in the same manner, now and then, in the succirubra gardens. They contain about 2 per cent. of quinine with 4—7 cinchonidine and 0·5—1·2 cinchonine." Some doubtful plants in Ceylon rich in quinine.

"Observations are detailed in the report on the best specimens on the estate at Kawah-Tjiwidei [about 1950 M (6,396 feet) above sea level] which show that there are certainly robustas having a high quinine value. Discovery in Java of plants rich in quinine

"In his quinological studies of 1892, No. v, the writer (van Leersum) discouraged the rearing of these Cinchonas, because the cinchonidine which abundantly occurs in them, had not only very little market value at that time, but their bark was difficult to work. Since then, however, this alkaloid seems to have become important in therapeutics, and at present the Bandoeng quinine factory pays 4 cents. per unit of cinchonidine, if the bark contains this alkaloid in the proportion of one-third or more of the sum of the percentage of pure quinine and pure cinchonidine." Demand for cinchonidine brings robusta bark to notice.

"With this in view it was decided by the Government in their letter No. 32 of the 9th November 1901, to extend the establishment at Kawah-Tjiwidei to the size of 150 bouws (1 bouw=1·75 acre) for the planting of the **C. robusta** and distribute 5 gr. of the seed of this plant free of cost to every partner of the Cinchona trial

C CHONA ROBUSTA.

station 'Institute DeVrij' to be sown, by way of experiment, on the private Cinchona estates situated on different elevations." This not only had the object of spreading this species but of obtaining true data as to the altitude at which this plant thrives best.

Official action criticised.

In "De Indische Mercuur" of January 21st, 1902, we communicated, by request, whatever was known about **C. robusta,** and in the subsequent number, of 15th April, we gave our opinion on the Government decision described above, which we called "a risky resolution."

"Alluding to those contributions van Leersum replied giving his reasons, but we will pass what he said about it, as we are at present concerned with the chemical researches on Robusta. It appears however remarkable that the seeds were only distributed to a certain class of Cinchona planters with the object pointed out. On the other hand they did begin at once to till on the highest situated estate of the 150 bouws, for the planting of Robusta. For a moment it had the semblance as if the cultivation was for the greater part to be converted into a Robusta plantation, as it is said in the report of the 3rd quarter of 1901 that 'if later on an unhoped for decrease in price of sulphate of quinine should occur again, then the Robusta will prove to be the buoy which will keep the enterprise from drifting.' Though this opinion was kept out of the report for the year 1901, observers might have been led to believe, that the future of Cinchona cultivation was to be found in **C. robusta,** in the same way as the Government enterprise threatened about 25 years ago to be turned into a succirubra plantation.

"However, it is not to be gainsayed that the Robusta, both on account of its ready growth and high alkaloid content, in which occurs much cinchonidine and quinine, affords an excellent bark."

Discovery of more rich robustas.

In 1902, "11 Robustas were examined. The highest yielded 9·10, 7·68 and 7·82 per cent. of sulphate of quinine, besides respectively 4·61, 5·82 and 7·29 cinchonidine, and total alkaloid 12·91, 14·41 and 16·16. At the height of a man's chest ten trees were from 49 to 76 c. m. (19 to 30 inches) in circumference. All are about 25 years old, and are, in respect of quality and growth, typical specimens with broad leaves."

A peculiar type.

"One **C. robusta** from Tjinjiroean is a peculiar specimen. The plant was discovered in 1885 in the succirubra nurseries at Kawah-Tjiwidei, and transplanted at Tjinjiroean on account of its peculiar type. The leaves do not resemble those of the Cinchona tree in a single point, they are more like that of the "Nangka" (*Anona*

muricata); they are light green and uncommonly leathery. Notwithstanding its unfavourable situation (in the yard of a foreman's dwelling) the percentage both of quinine and cinchonidine is rather high. CINCHONA ROBUSTA.

The report for 1900 mentions a **C. robusta** from Tjinjiroean with 5·51 sulphate of quinine, 5·11 cinchonidine and a total of 14·06 per cent. alkaloid. If, as implied, this plant appeared in the succirubra nurseries at Kawah-Tjiwidei in 1885, it could not be the off-spring of Robusta seed from Java nor yet a hybrid of **C. robusta** with **C. succirubra.** It deserves the special attention of a botanist. It is not stated whether this 17-year old tree gave any fruit; naturally when seeds are available they are sown and the behaviour of the progeny is observed. As regards the Robusta, the ten trees examined in 1902 and re-examined anew confirm again that this remarkable plant surpasses all the other cultivated Cinchonas in nearly every point. Quinine manufacturers, however, prefer the rich Ledger bark, because they derive more profit from it for manufacturing purposes. A very rich robusta discovered.

In 1905, "investigations were made in regard to manuring experiments on 1 to 2-year old Robustas grafted on succirubra. These showed a percentage of 1·20 to 3·21 quinine, with 1·02 to 2·99 cinchonidine, and 5·47 to 10·08 total alkaloids."

Second Quarter, 1906:—"In supplement 'B', some (97) analyses are to be found of the parent trees of the Robustas, and of the bark of 2 or 3 year old grafts of those parent trees, and also of 10 at 4 year old plants.

"Conclusions have not been drawn from the results of the 97 analyses, but it must be noted here that the $1\frac{1}{2}$ to 4-year old grafts which were examined, with the exception of three unimportant ones, did not come near the parent tree in quinine or cinchonidine content. This fact is striking enough seeing that the generally accepted rule was, that the alkaloid increases till the 4th or 5th year, and apparently decreases after this. The three exceptions are—parent tree No. 7 which contained 3·10 quinine and 4·35 cinchonidine, and in 4-year old grafts 2·45 and 4·60 respectively; parent tree No. 14 which contained 2·21 quinine and 8·46 cinchonidine, while the 4-year old grafts showed 2·28 and 4·69; parent tree No. 50 which contained 1·09 quinine and 5·76 cinchonidine as against 1·56 and 2·69 in the 3-year old grafts." Progeny (graft) disappointing. Grafts below parent trees in richness.

Third Quarter, 1906:—"In the report of the 3rd quarter of 1905 mention was made of the sending, through the 'Model-Apotheck' of the Amsterdam University to the Bureau voor Tannin in Robusta bark.

CINCHONA ROBUSTA.

Handelsinlichtingen, some bark of **C. robusta** and alkaloids, and pharmaceutical preparations, such as extract and tincture. This Cinchona hybrid seems particularly suitable for apothecaries on account of its large yield of alkaloids and tannic acid. A series of quino-tannin determinations is quoted in the supplement of this report. The Netherlands Pharmacopœia, ed. IV, is content with a tannin yield of 9 per cent. in Cinchona bark, but with Robusta No. 5 this figure runs as high as 23." In 8 analyses the percentage ranged from 9 to 23 or an average of 14·8."

Fourth Quarter, 1906:—"In supplement 'B' the tannin determinations of all the 72 original Robustas at Kawah Tjiwidei which were about 30 years old, are recorded; to which is added the alkaloidal value of the bark."

Consulting supplement 'B', it appears that the tannin percentage in 57 trees ranges from 5·5 to 27, and is on an average 15·5. The total alkaloid percentage of those 57 trees shows, for extreme figures, 7·93 and 16·16, average 11·15; the quinine percentage, on an average, was 4·69, ranging from 1·09 to 7·72 and the cinchonidine from 3·17 to 7·29, the average being 4·54.

Thus Robusta is really a remarkable Cinchona hybrid and deserves attention. If indeed the decrease after the 4th or 5th year may be regarded as a law, those 72 trees must have been exceedingly rich a quarter of a century ago.

Diversity in the hybrid.

Remarkable is the diversity among the individuals, and it should be determined after some years of experience, whether the progeny —vegetatively and generatively—remains in conformity to the parent trees.

"Regarding the Robusta plantations at Kawah Tjiwidei, 6,500 —7,000 feet above sea level, it can be noted that the last 30 bouws of land cleared in 1906 (of the 150 bouws referred to above) were planted, and the results as regards the growth, were very favourable.

"The tannin determination was made according to the method in Nederlandsche Pharmacopœia, ed. IV.

"That young specimens may have a rather high tannin percentage is proved by the examination of the bark of $3\frac{3}{4}$-year old grafts, originally from tree 42. No tannin determination could be made of this on account of its dying off, but the grafts showed 12·7 per cent.

Robustas good for stocks for grafting.

"The percentage of the success with grafts and the growth of Ledger on Robusta is not inferior to that on succirubra, so that the

planter in future will not be excused, if he continues to use stocks of succirubra, which are so low in quinine, and the barks of which are practically valueless." CINCHONA ROBUSTA.

1907. "Two analyses of a Robusta parent tree and of 2-year old seedlings of that tree gave respectively 27 and 13 per cent. of tannin."

"Three Robustas of 30 years old appeared to contain respectively 6, 5·80 and 7·10 sulphate with 1·64, 4·89 and 3·99 cinchonidine, besides 22·5, 24 and 14·8 tannin, and some Robusta grafts had already, at 5 years of age, a higher percentage of alkaloids and tannin than the parent trees."

Location and Distribution of Alkaloids.

It was the opinion of Weddell, Karsten, Wiegand and others that the alkaloids were located in the liber or inner layer of the bark, but Howard, Carles and Moens have shown by their investigations of various species of Cinchona that the alkaloids, especially quinine, are contained more in the outer layers. ALKALOIDS in outer bark.

In 1877, "researches confirmed what has been accepted, that the outside layers of the bark (primary) contain more alkaloid than the inside (secondary layers.) The difference was very distinct in four species examined:—**C. javanica, C. micrantha, C. lancifolia** and **C. succirubra.** Not only were the inside layers found to be poorer in total alkaloids, but the alkaloid which is known as the best febrifuge had decreased, whilst cinchonine was left in comparatively greater quantity in the layers next the cambium."

In 1879 "twenty-one analyses were carried out on as many parts of the bark of a 12-year old Ledger, in order to ascertain the location and nature of the alkaloids over the whole of the tree, including the branches and the roots. This investigation taught (so says Moens), that with this tree the bark is rich in quinine over the greater part of the trunk, whereas the bark of the upper part of the tree and of the smaller branches gave a smaller amount. Bark at 6½ and 7 metres (21·3 and 21·9 feet) above the ground gave respectively 4·76 and 1·72 per cent. of quinine, whilst for instance 1·5, 10 and 15 d. m. (·49, 3·28 and 4·92 feet) above ground contained respectively 7·63, 8·17, 9·04 and 9·30 per cent." There was found 0·64 in the small branches, 4·63 in the medium, and 7·40 in the larger branches. Stem bark richer than branch bark.

"There were differences inexplicable in so far as bark at 5 metres (16·4 feet) above ground was about as rich in quinine (9·24

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per cent.) as at 1½ metres (4·92 feet) (9·30 per cent.) whilst the parts between contained less."

Quinidine in root-bark.

"It was in harmony with previous experience that the root-bark contained much more cinchonine than the trunk-bark, and it was remarkable that the quinidine only appeared in the root-bark, and not at all in the trunk-bark: 0·11 and 0·27 per cent. were found respectively in the thickest and thinnest roots."

In 1880 "from the wood of the stem and root of a Ledger tree a comparatively large quantity of pure quinine was extracted, 0·27 and 0·09 in 0·50 and 0·46 of the total alkaloids. In its leaves only traces of alkaloids were found, the nature of which could not be determined."

Structure of wood of Cinchona.

It must be mentioned that the wood of Cinchona trees shows a peculiar deviation in structure which appears in several other tropical trees. Weddell was the first to notice this peculiarity, and Dr. Lotsy (in his important treatise "The Alkaloids of the Cinchona Tree, No. 1 of the Mededeelingen van het botanisch laboratorium der Gouvernements—Kina-onderneming, 'S lands drukkerij, Batavia, 1898, in describing the wood of **C. Ledgeriana** noted that in it there appear more living elements, than in the wood of most species of trees, and that the medullary rays are united to a greater extent."

In 1894, "the branches of a tree containing 11·70 per cent. of quinine were divided into several equal parts, and the barks of each part were examined." The bark at the lowest or thickest part of the branches showed 10·25 per cent. and that of the other parts from 7·35 to 9·44 per cent.

In 1895, "105 analyses were carried out on the same subject," though "only after repeated investigations can rules be fixed; from further examinations made in the year it seems that there is a lower alkaloid content in the bark of branches with a circumference of 3 to 4 centimetres than in the younger trees."

Bark of diseased trees.

"Sixteen analyses showed that bark of the higher part of the trunk contained more quinine than that of the lower parts. The cause of this phenomenon is probably due to more or less excessive cork formation, which takes place at the lower stem of the older specimens, and as this incrustation contains very little alkaloid, it would naturally, when mixed with the other parts, reduce the percentage. Eight analyses out of 16 were made on the barks of diseased trees and showed that the percentage may be much lower than that of sound trees of the same species and age."

In 1897, "the investigation into the distribution of alkaloids in the stem was continued. The trunk bark of a Ledger was cut into

pieces of 25 c.m. in length and each of these was examined separately." It would appear from these results that up to ½ metre above ground the quinine content ranges from 6 to 6·40 and goes down to 5·50 at a height of 2 metres, while at a height of 1¾ it is 5·40, From 2 to 5½ metres it rises again to 6·2, but irregularly, and declines to 5·90 at 4¾. From 5½ metres and upwards the figures steadily decrease and at 8¼ metres they fall to 2·60.

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In 1905, "investigations were continued into the alkaloidal value of the Cinchona plant. As far as they went it was accepted as definite that alkaloid certainly appears in the seed, both as amorphous and cinchonine. This is contrary to the statement of Moens (De Kinacultuur in Azië, p. 301) and of Dr. Lotsy (Mededeelingen van de Laboratoria der Gouvernements—Kina-onderneming, p. 97).

Lotsy's work on connection between age and formation of alkaloids.

"Not a trace of quinine but the so-called amorphous alkaloid could be detected in (1) the stamens of the ripe opened flowers; (2) of unopened flowers; (3) the pistil of the opened and unopened flowers; (4) corollas of opened and unopened flowers; (5) the ovary of the opened and unopened flowers including the calyx teeth; (6) the entire small unripe flowers (corollas, stamens, etc.); (7) small ovaries including the calyx but excluding carolla, stamen and stigmas; (8) bracts (cinchonine was found in these according to the report of the first quarter of 1906); (9) dehisced fruits without seeds; (10) in opposition to the statements of De Vrij and Behrens cinchonine was found in young and old leaves, see Lotsy in Mededeelingen uit 'sLands Plantentuin, xxxvi, p. 18; (11) in seed that had germinated for ten days, amorphous and cinchonine, showing that the alkaloids had not changed; (12) seed that had germinated 20 days, still containing cinchonine and amorphous; (13) of seed that had germinated 28 days and just started producing buds at a height of 1,566 m. (5,136 feet). In closed nurseries and in pots the production of buds took place in 12 or 14 days at the same altitude. One thousand plants weighing 200 milligrammes were examined, and cinchonine and cinchonidine were shown to be present, the latter less than the former. Evidently it is formed during germination; (14) plants two months old were examined (*a*) first leaves, cinchonine was found, (*b*) the stems, no trace of quinine or quinidine, but cinchonine and cinchonidine were found, (*c*) the roots, cinchonine and cinchonidine were found; (15) plants nearly 7 months old;—leaves, stems, and roots, no trace of quinine or quinidine, but cinchonine and cinchonidine; (16) the plants 10 months old, the same parts were examined with the same results."

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In 1906, "the microchemical research was continued on the alkaloidal contents of young plants. The root, stem and leaf of 10-month old plants were examined. No trace of quinine and quinidine could be found, but on the contrary there was rather a quantity of cinchonine and cinchonidine. The same results were obtained with plants from the 'Rioengoenoeng mixture' of seedlings from the 11 or 12 months old nurseries."

"With the stem and root of plants about 13 or 14 months old the clear liquor with sulphuric acid fluoresced distinctly, but the alkaloid was not determined."

"From researches of 1905 it had been affirmed that mutual transformation of alkaloids takes place in the plant. This was again proved from the examination of stem, root and bark of 9 months old Robusta plants. Robustas contain less quinine but more cinchonidine than Ledgers from the seed of the 'Rioengoenoeng mixture.' The investigation showed that in plants 9 months old less cinchonidine and cinchonine occur than in the Ledger plants of the same age and from the same 'mixture', and it was clear that the stem contained more crystalline alkaloids than the root." It should be remembered that the formation of alkaloid may commence in the leaf and root, but that only in the branch and stem it reaches its limit.

Priority of formation of alkaloids.

"The examination of 13 months old plants, reared from seeds of Ledger 23, showed that (using a larger quantity) the fluorescence is caused by quinidine (quinine, hydroquinine and cupreine are also fluorescent). So that according to the results up to the present, the alkaloids rank as follows:—CINCHONINE, CINCHONIDINE, QUINIDINE. It is peculiar that in the bark of the trees from the same seed—typical Ledgers—the quinidine exists in traces and was neither found by Moens in the parent trees Nos. 23 and 38, from which originate the gardens which supply the seed No. 23 and 'Rioengoenoeng mixture.' As regards cinchonidine, the same fact was also discovered, *viz.*, that in proportion to other alkaloids, much cinchonidine appears in the young plants, and proportionately less in the barks from the same seed."

Quinine first forms in root.

"Typical also is the phenomenon discovered in these investigations, that from 12 grammes of the root of plants No. 23, 13 months old, a crystalline compound of tartaric and oxalic acid was obtained which gave the herapathite reaction, a result which points to the presence of quinine; when 25 grammes of stems were examined this did not happen."

"Working on 20 grammes of root of plants of 'Rioengoenoeng mixture,' 16 months old, 0·16 grs. of tartrates were obtained, consisting chiefly of cinchonidine and only traces of quinine." LOCATION AND DISTRIBUTION OF ALKALOIDS.

"No tartrate of cinchonidine or quinidine was obtained in a quantitative determination of the alkaloid in 2 × 20 grammes of the stem. Probably the crystallisation was arrested by impurities such as happens when the bark of very young cinchona plants is examined."

"Judging from the examination of the root and stem of plants No. 23, 13 months old, the possibility is not excluded that quinine forms sooner in the root than in the stem."

"Ledger roots of plants 18 months old were next examined and yielded: quinine 0·5, cinchonidine 0·54, total 2·7 per cent. In the stem of the same plants was found one quarter of the tartrates present in the roots."

"12 grammes of the roots of Robusta plants, 13 months old, afforded 0·094 grs. of tartrates, while from the stems no tartrates of quinine or cinchonidine could be obtained."

"It is apparent from the above figures that in the root of very young plants more quinine and cinchonidine is present than in the stems of the same plants, and the researches show more and more that the quinine is formed sooner in the root than in the stem." More alkaloid in young roots than in young stems.

"It is interesting in connection with this statement to open the old reports of 1859-63. The Pahudiana for instance was disappointing in the poverty of its bark, but the great difference in the root and stem bark gave De Vrij and Junghuhn great encouragement for the future."

In 1896 a systematic research was started by Dr. Lotsy on the alkaloids in the leaves of **C. Ledgeriana.**

No definite results were obtained, but everything pointed to the fact that the upper leaves are richer in alkaloid than the others. Alkaloid in leaves.

1900. "The investigation was continued in 1900 and the results were communicated in the 'Mededeelingen uit 'sLands Plantentuin, Deel XXXVI.' The subject is elaborately treated and it is explained where the alkaloids form in the tree. The author comes to the conclusion that in the Cinchona tree the alkaloid is formed in the leaves, and transmitted from them to the stem, where it remains either in its original form or in the form of a new compound from which another alkaloid is developed." Dr. Lotsy's results.

"With this conclusion Dr. Lotsy does not absolutely exclude the possibility of the formation of alkaloids in the bark itself, but

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on the ground of experiments he concludes that it is far behind that which is formed in the leaves."

Van Leersum's results by defoliating.

Van Leersum approached the subject from a chemical standpoint. He proposed "to find a final proof of the theory by simply taking off the leaves from the tree, keeping it leafless for a considerable time, and then seeing what influence it had on the alkaloidal content. If the alkaloid chiefly forms in the leaves, then the amount must decrease or disappear if the leaves are removed."

"Twenty-five analyses connected with experiments in this direction were carried out in 1900, and it was found that after the trees had been kept leafless for 24 months, an increase of 1·26 to 1·42 per cent. had taken place."

"In some cases the increase appeared to be extraordinary, for instance 24 analyses showed after six months an increase of 2·59, 3·12, 3·70, 2·63, 2·16, 2·40, 1·75 and 2·96 per cent. of quinine." There is a great difference between six and twenty-four months, and it appears from the table of analyses that the increase in the first six months was followed by a decrease in the subsequent months. Removing the leaves not only enhances the value of the bark of Ledgerianas but also that of the Ledger and succirubra hybrid, and it is evident that the increase took place more or less after the trees had been from 2 to 12 months without leaf.

Dutch botanists' advice for further work.

"In consequence of a correspondence with the botanists Prof. Van't Went and Verschaffelt, of Holland, it was decided to examine in future the bark of part of the trees every 2 or 3 months instead of every six months. The result of such an investigation would be in accordance with another fact, *viz.*, that the shaded trees are richer in alkaloid than those of the same kind which are planted at the borders of the plantations and have the strong sunlight."

"Another series of analyses was made with interesting results. The barks which had been examined before the cutting of the leaves contained 6·24, 5·00, 7·73, and 6·46 per cent. of quinine. After the trees had remained leafless for six months, the barks were re-examined and found to contain 8·4, 7·4, 9·48 and 9·42 per cent. The trees were left alone for another six months to allow the leaves to sprout and then examined; they yielded 8·37, 6·73, 8·92 and 9·33 per cent.; a decrease in quantity."

"A manager of a cinchona estate in South Preanger, who had to improve an estate and to bare the trees of their leaves, found as a result of 23 analyses that the quinine content in the bark increased from 6·10 to 6·65, and the total alkaloid from 8·62 to 8·99."

"The question with regard to the action on the root-bark when the trees have been deprived of their leaves had been answered by four analyses. An increase was not found; but it must not be forgotten that such investigations are very difficult, because the root-bark can never be perfectly freed from the particles of earth without damaging the epidermis, and, moreover, it is hardly possible to obtain sufficient root-bark of an equal depth for an analysis."

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Root bark of defoliated tree.

From a biological point of view and in expectation of the results of further experiments, we may doubtless consider these of much importance and use, but we would adhere to our conviction that it will never be practicable to obtain quinine by denuding cinchona trees of their leaves, although it can be done for temporary purposes, because we know the usefulness of the leaves and the expense which the process involves, matters that should be taken into consideration where financial profit is concerned.

Removal of leaves not desirable.

"It is possible that an advantage may be discovered in taking the leaf from the plantations some months before the crop, provided that the peeling of the bark is not rendered more difficult by the process."

A possible means of getting an advantage by defoliating.

In 1901, "180 analyses confirm the fact, discovered already in 1900, that as soon as the systematic removal of leaves stops and the trees have grown leaf again, a decrease of alkaloid is observed."

"This decrease, however, is not the same in all specimens. Those which stand close and consequently have not such an abundance of leaf as those which are subjected to light, the decrease is slighter than with the latter."

Loss of alkaloid on renewal of leaf.

"With trees which have been ringed just under the crown, where there is no growth of leaf, the crown having been killed, the quinine percentage of the bark remained either at the same height, *i.e.*, if it was 9·10 per cent. before the ringing took place it was 9·80 and 9·50 after 12 and 13 months respectively (such differences are of no importance), or it increased: 7·40 to 7·76 and 8·51 per cent. after 12 and 13 months."

Effect on alkaloid of ringing the trees.

"When the whole crown had been removed and the tree had been left alone for six months, it appeared that the amount had decreased, while before that when the shoots in the trunk were regularly cut off, the amount had increased."

Effect on alkaloid of removing crown.

"It was impossible, as before (and for the same reason) to definitely settle what influence the removal of leaf has on the percentage of the root bark."

An experienced Cinchona planter writes: "The results of removing the leaves are very interesting. Practice showed here, that

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Effect of attack of Helopeltis.

some Ledger seedlings from the seeds which I collected last year from the mixture Rioengoenoeng, contained only 10 per cent. sulphate quinine, because they had been damaged by Helopeltis to such an extent, that they were on the point of dying and for some successive years stood leafless. If, therefore, the quinine formation took place in the leaves, the results would have been quite different. Many Ledger trees which had for some time been attacked by Helopeltis gave as a rule very thick bark."

"Moreover, some one else told me that he had observed that Ledger seedlings from parent tree seeds, which had been attacked for some time by Helopeltis, yielded more quinine in the bark than the Ledgers of mixture Roengoenoeng."

Damage by Helopeltis and caterpillar.

Such observations must be regarded as interesting, as other Cinchona planters fear the Helopeltis plague and call it the greatest Cinchona pest, and spend much trouble and expense to keep it within bounds by constantly destroying the insect. Moens and myself always regretted to observe that all our efforts to guard against the new attacks were of no avail. It is of great importance to investigate thoroughly and carefully, what influence the combined denuding of the trees by Helopeltis or caterpillar had on their development. It is said that the bark gets thicker, which is quite possible, but must that be accepted as a rule? Practically this is indeed one of the most important questions which demands the attention of the Cinchona planters.

Renewed experiments in defoliating.

In 1902, "229 analyses concern the problem about the location of the alkaloids. As had been noted on the subject in the report of 1899, it was proved again that after 12 months the alkaloidal content showed a considerable increase, while when a tree is left alone for its leaves to grow again, the alkaloid after the same period went down to the level of what it was before the experiment. Remark the results of the two following tests—45, 52:—(1) the control sample of bark taken before the tree was deprived of leaf contained 8·32 quinine; the bark of the same tree after having been without leaves for 12 months contained 9·22; six months after the formation of new leaf 9, and 14 months thereafter 8·50 per cent. which is about the same as the control; (2) the control sample before the leaves were removed contained 8·08; 12 months after 8·90; 6 months after the formation of new leaf 8·82, and 14 months after this 8·19 per cent."

In 1903, "for comparative experiments, regarding the location of alkaloidal formation 12 Ledgers and 12 hybrids were taken. From each plot, in January, half was deprived of its leaves and

the other half was kept intact. The bark was then analysed once, and again in July. Four leafless trees appeared to have increased, but four showed a decrease in quinine; the other 16 all showed a decrease again . . . in the same proportion. LOCATION AND DISTRIBUTION OF ALKALOIDS.

After all we have heard about the favourable effects in the quinine percentage by denuding the leaves, it might be inferred now that the question has been settled, but the following statements again urge the postponing of pronouncement.

"Leaving aside the impracticability of removing leaves on a large scale the above experiments lead to the following conclusions:—

"(1) That the denuding of the leaves is not recommendable in practice because in cultivation the main object is the quantity of sulphate of quinine per given area.

"(2) In many cases it may be more profitable to rear broad-leaved quick growing Ledgers which yield much thicker bark with less quinine than narrow-leaved ones which grow slowly, and therefore produce less bark but of a high percentage." Conclusions regarding defoliation.

"It is hardly to be recommended to destroy a plantation of 4-5 years old, when the trees have reached their maximum quinine content, because it is only after this age that the important increase of bark begins."

"As it has been observed previously, the analyses showed again (1) that the increase in alkaloid is not the same in all specimens, (2) that the long duration of the 'disleafing' process has decreased the percentage, and (3) that other influences have been at work, which appear from a number of analyses of check-trees standing in the vicinity which had not been denuded of their leaves."

Root-Bark.

In 1873, "the root-barks of **C. javanica, C. Calisaya,** Schuhkraft, and **C. succirubra** were examined and agreed very well in composition with that of the stem-barks of the same species. If any difference is to be noticed, one finds that the root-bark generally contains a little more cinchonine than the trunk-bark." ROOT-BARK contains more cinchonine than stem-bark.

"Whilst the percentage of quinine in root-barks is generally not higher, often lower than that of the trunk-bark, the analysis of a **C. Pahudiana** in 1875 showed that the trunk-bark contained only 0·32 per cent. and the root-bark 2·47 per cent. of sulphate of quinine."

In 1889, "from a series of analyses of the root-bark of Ledgerianas, it appears that even with young trees the bark of the thicker

ROOT-BARK.

roots reaches a higher content of quinine and the bark of the thinnest part of the roots possesses a not inconsiderable amount of alkaloid."

"This observation could certainly not be called a surprise because a quarter of a century ago the comparatively large amount of alkaloids in Cinchona roots was pointed out, and for this reason De Vrij recommended the growing of Pahudiana plants for their roots, like madder. Later on the investigation of the roots has not been neglected as the subject had also a physiological interest. (See Location and Distribution of Alkaloids, p. 65.)

More alkaloid in thin roots.

In 1904, "15 analyses relate to the alkaloids in the roots of succirubra trees. The following samples were separately examined: (1) the bark of the main root, (2) that of the roots of the size of the wrist, (3) that of the size of the thumb, and (4) that of the thin roots. It appears from the results that the thinner roots contained more alkaloid than the larger ones, which gave rise to the suspicion that the roots take part in the formation of alkaloid from the ingredients of the soil."

In 1907, "as it had been found in 1889, it was again shown that the bark of the main roots of the Ledgers contain much less quinine than those of the lateral roots, so much so that from those of the latter, of the size of a pencil, 7·5 per cent. of quinine sulphate was obtained, while bark of the main root with a circumference of 50 c. m. only gave 4·10 per cent."

Influence of Sunlight.

EFFECT OF LIGHT ON ALKALOID.

In 1903, in the Nederlandsch Tijdschrift voor Pharmacie, Chemie en Toxicologie, for the year 1892, I published a contribution on "The influence of sunlight on the quality of cinchona bark" as a rejoinder to an essay which appeared in the "Traité de Medecine," Vol. 1, page 698, by Chantimesse. I drew attention to Pasteur's investigations regarding the easy transformation of the cinchona alkaloids—quinine, quinidine, cinchonine and cinchonidine into the isomeric quinicine and cinchonicine, and noticed that in British India and in Java, Pasteur's advice "to protect the bark of the cinchona trees against the light" was followed for 20 years with the best results by covering the stems and branches of the trees with moss.

Pasteur's researches.

"The results we learn to appreciate according to their value, but the following from Pasteur's publication in the 'Comptes

rendus' of 1853, is still worth attention:—'I shall not go into details regarding my experiments with the quinoidine, but there is one point to which I should like to draw the attention of the quinine manufacturers and of the companies that collect cinchona bark in America. The quinoidine is a transformation product of the original cinchona alkaloids, from two different sources. It developes in manufacturing the sulphate of quinine, and especially in the forests of the New World where the cascarilleros dry the peeled bark in the sun. Then the cinchona alkaloids all undergo a metamorphosis in the bark and change into coloured resinous substances which form the bulk of the commercial quinoidine.' (Note:—Since 1830 this so-called quinoidine has kept many chemists busy, amongst whom we may mention the promising Military apothecary, Van Heyningen, who died so early, and who as far back as 1849 separated β quinine. De Vrij gave in 1876 the name of chinoidine to the amorphous alkaloids, and under this name they appeared in the second edition of the 'Netherlands Pharmacopœia.') I have already discovered that when a quinine or cinchonine salt in a thin or concentrated solution is exposed to the sunlight for a few hours, it assumes a dark brown colour. The same change takes place by exposing it to a high temperature. Therefore I believe that great loss of quinine, cinchonine, etc., could be prevented, and that these alkaloids could be better manufactured if precautions were taken to remove the peeled bark at once from influence of the light and to conduct the drying in the dark. The quinine manufacturers should also avoid all influence of the light."

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Light and heat detrimental to alkaloids.

"The above is what Pasteur said in 1853. If light and heat are both detrimental it becomes serious and we shall have to declare ourselves powerless to remove the whole evil. It is very probable though that there is a difference between alkaloids in solution and those still preserved in the bark. At least the yellow brown bark of the older trees, both through the outside corky layers and the moss on it, is so well protected from the light that it would be strange if the chemical rays could effect any change on the alkaloids.

"On account of their chemical constitution the alkaloids have been divided into different groups and the quinine shows, in its rather complicated molecules, a pyridine nucleus. Many chemists have certainly tried to manufacture quinine from its allied alkaloids, but up to the present they have not succeeded. Only Grimaux and Arnaud obtained in 1891-92, by treating cupreine

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with methyl-iodide and alkali, a methylcupreine which proved identical with quinine.

"Science has so far not accomplished what nature does in the living tree."

Mossed and Renewed Bark.

McIvor's theory.

In his note of 1867 "on the propagation and cultivation of the medicinal cinchonas," McIvor gave a detailed description of his mossing system, its aim and working.

His opinion was that quinine and other alkaloids are formed in the leaves of the trees combined with quinic acid and are subsequently deposited in the bark, where with the increase of the cell tissues, an increase of pure quinine would take place. In this cell tissue of the liber, against the constant deposit of alkaloid, a decrease of quinine should take place in consequence of the influence of light and air on the bark. If this oxidation process, so thought McIvor, could be arrested, the quinine formation or increase would steadily continue in the succirubra bark and come up to 17 per cent. The means to prevent this oxidation process was found, according to McIvor's statement, in the exclusion of light and air by moss covering.

It is necessary to point out that McIvor worked with his theory in front, and a man in such a position tends to see in practice what he expects to see; whereas the better and far safer course is to set the establishment of facts in front, and let the theories follow.

History of 14 years' experiments from 1864 to 1878.

These experiments reported in Holland.

Interest taken in them slight.

For the accurate estimate of its value and for the completeness of its history, it may be useful to record here what was stated in the meeting of the Koninklijke Academie van Wetenschatken on November 8th, 1878, under the title of "Scientific remarks and experiences concerning cinchona cultivation."*

The covering of the living cinchona trees with moss. (McIvor's mossing process.) In the report of 1864 it was recorded that—"in consequence of the advice given by De Vrij, we have, after the example of McIvor, covered some trees with moss. The moss keeps the trunk in a very damp state, and it is not improbable that to this (and the exclusion of light) may be ascribed the higher percentage of alkaloid observed by De Vrij. In a few months comparative tests will indicate the true influence."

* "Wetemachappelijke opmerkingen en ervaringen betreffende de kinacultuur."

These mossing experiments, it must be confessed, "were undertaken with some disinclination if not with prejudice."

MOSSED AND RENEWED BARK.

In Java, in 1864, hundreds of cinchona plants were covered with moss, and the chemical experts, De Vrij and Moens, had the opportunity of investigating the results. The analyses, however, did not lead to any conclusions. Moens (report 1870) discovered an increase of alkaloids in four plants which had been covered with moss for a year and which had been examined before the operation.

Could this slight increase be ascribed to the moss, or was it the result of the maturing of the plants?

De Vrij's experiments.

De Vrij examined two specimens of the same age, growing together, one of which was covered with moss. In the moss-covered specimen 1·075 per cent. of alkaloid was found, but without quinine re-action, while in the unmossed bark 0·07 was found with distinct quinine re-action.

Comparing the results obtained by our earlier experiments with mossing, it shows that theories should not be built upon. The experiments in themselves were not sufficient, nor were they carried out with much care (a fact we have mentioned before). This may have been the cause of so many plants dying in consequence of mossing after having been attacked by insects.

On the persuasion of De Vrij, Moens had repeated the experiments on the English method for 3 or 4 years, but with another object. It was said that quinine bark forms vigorously again under moss. Often had we to strip a tree partially of its bark, either for analytical researches, or for the herbarium, or for exhibition. This caused very little damage, as the regrowth of the bark took place every time more or less quickly. If the cambium layer is injured when the bark is being taken off, a speedy and complete recovery cannot be expected; but if the bark is only partly removed there is a chance of quick and complete restoration.

Cambium to be left intact.

Moens' experiments favourable.

The experiments repeated by Moens appear to prove that the covering with moss certainly facilitates the forming of bark and increases the percentage of quinine. The experiments must succeed the better if they are made on trees which are not too old and stand in well closed gardens. The renewed bark could be peeled off easier and cut into strips. Thus Moens is favourably disposed towards the covering with moss; but this statement is not only deemed premature as yet, but I think this method will never come into general practice unless sound proof is furnished that the profits, through the increase of quinine, are considerable. The

MOSSED AND RENEWED BARK.

results obtained from investigation of specimens do not justify the introduction of any costly method, since the quantity and quality of alkaloid varied so much.

A costly method.

Moens only took into consideration the cost of mossing, but one must not forget the further cost of removing it.

Fourteen years have now been spent in experimenting on the mossing system with the objects, first to enrich the quinine bark and then to facilitate its renewal, thereby increasing the richness of the quinine; and it is surprising to note that it should be still continued. In British India, where the business was being carried out with untiring energy, decisive results should have been obtained, as 14 years is a life-time for a cinchona plant transplanted in foreign soil.

Experience in Bengal.

"But note what Dr. O. Kuntze says in his 'Monografische Studie nach Beobachtungen in den Anpflanzungen auf Java und in Himalaya, 1878.'* The experiments to regrow the bark on the living tree, after stripping off the bark and covering it with moss did not lead to any practical results in Mungpoo, because the process is too slow and is not worth the labour spent on it."

The question of moss covering is still in hand, but now another point has arisen, *viz.*, the location of the quinine (see the annual report of 1877, p. 65) where it is said "the alkaloids, especially quinine, are contained more in the outer layers."

McIvor's process of stripping and mossing.

In 1878, "22 experiments were made relating to the 'mossing and stripping process' as conducted by McIvor. The result of this process was said to be that the strip of bark which was covered with moss was better than an unmossed strip of the same tree examined a year previously."

First experiments inconclusive.

"The observations could not be considered quite conclusive, as the barks were now a year older, and the increase in alkaloid could be ascribed to this, as all the trees had probably not reached the age when the bark yields its maximum. The renewed succirubra bark surpassed expectation, as the 19 months old pieces that were cut out contained on an average 3·29 per cent. of quinine.

Differences in different parts of the renewed bark.

"These experiments also showed that although new bark grows all along the strip at the same time and is therefore of the same age, the lower part generally contains more cinchonine than those above it, showing that the composition is not the same over the whole length of the strip. This changed proportion of the alkaloids from what they were in the original bark, which had taken place

* "Monographical study on observations regarding the plantations in Java and the Himalayas."

at the time of renewal, demands attention, and a study of this phenomenon should be very interesting when applied to other species."

MOSSED AND RENEWED BARK.

Though the reports on Cinchona after 1878 contain much about the "mossing and stripping process," it may be remarked here that as this process became obsolete long ago it may be dismissed briefly. In practice, not much benefit has been derived from it, but it is desirable to methodically review the experiments in order to have a fuller knowledge of the chemistry of the life history of the Cinchona.

Continuation of mossing experiments in 1879.

In 1879, "new bark was taken from the five test trees shaved a year previously. One of them was left uncovered, three were covered with moss, and one was covered with palm leaves. These barks showed a remarkable likeness which led to the conclusion that at least at the commencement of the regrowth (say one year), a bark of constant composition is formed as regards alkaloidal content. The formation of so much cinchonidine in this young tissue (as is seen in renewed succirubra bark) was peculiar."

At the commencement of regrowth, bark under all ordinary circumstances seemed the same.

"In four test trees the percentage of alkaloid, chiefly quinine, had not reached the original limit, but one tree showed more in the renewed bark (8·00 per cent. quinine against 7·90 per cent.) which led Moens to note that this was not due to the moss covering, for then the two other covered trees should also show an increase."

"The investigations on the renewed succirubra bark were also continued, but no decrease in the percentage of quinine was observed. On the contrary, there semed to be an increase. The renewed bark 26 months old, even appeared to be of very high value (4·29 per cent. quinine against 4·17 per cent. after 19 months, at which age however 3·26 per cent. and 2·96 per cent. have also been noted)."

Shaving and Renewing.

RENEWAL OF BARK AFTER SHAVING.

In 1880, the difference between the original and the two-year old renewed bark of **C. officinalis** and **C. Calisaya** of Schuhkraft is thus referred to:—"In general, the renewed bark contains a little more quinine, but shows a great decrease even to disappearance of the whole quantity of cinchonidine which on the average was in the original bark. The quinidine increases with the quinine." The increase in quinine in Schuhkraft's Calisaya was so slight that the partial shaving of this species was abolished. "The investigation of the renewed succirubra taught that the nature of the covering makes little difference in the nature of the alkaloids. The bark

Renewed bark of Calisaya poor in cinchonidine.

SHAVING AND RENEWING.

Nature of covering immaterial.

restored under Indjoek (palm leaves) showed the same increase in quinine and the same decrease in cinchonine as that restored under moss, a fact which was noted in the bark renewed without any covering. The renewed bark of a young Ledger tree in a private plantation 'Djajagiri' was also very rich. In 1879 a strip of bark which then contained 5·88 per cent. of quinine in 7·44 total alkaloids was taken from this tree. About a year later, the tree was uprooted by a storm and the renewed 11 months old bark was collected. An analysis showed that it contained 6·86 per cent. of quinine in 8·79 of total alkaloids."

If these figures are typical the result is very remarkable. The higher yield of alkaloid, especially of quinine, in the new bark of about 11 months old must give rise to thought and urge physiologists to a serious study of the subject. It is no longer an astonishing fact and already in 1880 did not cause astonishment that the alkaloidal content can increase in 11 months' time.

In this case nothing is said about the increase in the original bark but only in the newly formed bark on the old trunk. The original bark of the young tree appears not to have been analysed at the same time, which is to be regretted. An analysis of young stem and branch bark of 4 to 5 year old Ledgers, belonging to the same garden, gave 3·27 per cent. of quinine in 5·86 of total, no cinchonidine, but 0·25 per cent. of quinidine.

Moens attributed change in alkaloids to restoring process.

In 1881, "fresh experiments confirmed Moens' former opinion that the increase of quinine and the decrease of cinchonine in renewed succirubra bark is not due to covering the tree but to the restoring process itself; a fact also shown in officinalis."

Renewed bark three years old exceeds original in richness.

1882. "Previous investigations showed that the shaved-off Ledger bark, on renewal after one or even two years in 15-year old trees, had not reached its former quinine content. Now a number of trees had been allowed three years to form new bark, and analysis showed that the shavings of this new bark contained 9·26 quinine, this being about 1·5 more than the original 12-year old bark which according to a sample analysed in 1879 contained 7·8."

1885. "In this report a review is given of the practical results obtained by partly shaving the trees. In 1883 Van Romunde wrote:—'The bark collected by shaving from the original Ledger trees was now three years old **at which age the quinine content exceeds that of the original bark.'**"

Shaving considered a success, and definitely introduced.

"Some young trees were subjected to the operation for the first time. The trees were shaved only half way round the circum-

ference and not covered up afterwards. The results proved that no damage was caused by the operation. The young Ledgerianas had not been shaved till then, because it was not thought advisable to hinder them in their growth at an early age." SHAVING AND RENEWING.

From these notes it appears that the operation was considered a success, and that the so-called shaving of the bark was definitely introduced.

"The rule adopted was not to shave trees the stems of which had not reached a diameter of 6 centimetres ($2\frac{5}{12}$ inches). For officinalis a diameter of 5 c. m. (2 inches) was fixed." Rules adopted to regulate shaving.

"In order not to disturb their growth, only half the circumference was operated upon."

"It was found that the east monsoon was best adapted for this method of harvesting as the weather then was comparatively settled."

"After considerable crops of Ledger and officinalis shavings had been obtained in the months of July and August, the experiment was continued with strips of those trees the half of which had not been touched."

"The result was satisfactory in all respects" (a very unsound opinion van Gorkom thought). "In some plantations not even a trace of deterioration was found. Experience, however, showed that it is desirable to allow a lapse of at least $2\frac{1}{2}$ months between the two harvestings, and that thorough tilling is needed with this method of harvesting" (doubtless a fatal one).

"With the crop of 1885 (216,359 kilos) there was a considerable quantity of Ledgers which, as the result of the shaving method carried out on a large scale in 1884, turned sickly and threatened to die." Ill-effects of shaving appear.

"A last attempt in applying the shaving process was made on an old officinalis plot at Kawah Tjiwidei, but the result performed on a large scale in 1884, appeared so unfavourable that this method of harvesting was abolished for good." Method of shaving abolished in 1884 and reasons for abolishing it.

"All the shaved trees kept for the greater part their fresh and healthy appearance, but with those trees which had produced one crop by shaving half of their circumference, the untouched part a year later appeared to have grown much more than the shaved portion."

"A few careful experiments were made later to show the difference in development both with and without the covering of the exposed part."

SHAVING AND RENEWING.

"The bad consequences of the shaving process, applied in 1884 were first felt in the beginning of the second quarter of 1885, when especially in Tjibietong, Rioengoenoeng and Tjibeureum a considerable number of trees, originally estimated at 5,000, began to wither in such a manner as to render it necessary to remove these sickly trees."

"The methodical shaving of the whole of the circumference of the trees was exclusively applied to Ledgerianas of inferior quality, and therefore the damage caused by a subsequent premature harvesting of the trees was not very important."

Shaving not suitable in close plantations.

"In the closely planted gardens at Rioengoenoeng which only produced one crop of Ledger chips, the shaving process gave less successful results. No plants died, but they were withering away for some time, and through the long rains the bare parts of the stem of a few began to rot."

It will be evident in future that the trees in close plantations cannot sustain the operation without risk, and the shaving process will have to be entirely abolished. And great advantages are offered by close plantations. They tend to yield a maximum of produce with a minimum amount of labour, while a large amount of humus improves the physical and chemical properties of the soil.

"The application of McIvor's method not having answered expectations (which was apparent beforehand), the results of shaving the bark were so bad that its continuation was not justified. Nothing remains but to systematically thin the plantation, together with limited cutting out and final uprooting of the whole." (This is exactly what was considered the most rational method described in the reports for 1864-65.)

The only occasion when shaving is worth doing.

The system of shaving can only be serviceable if a sudden rise in the quinine market necessitates a temporary large produce, and if want of funds compels the planter to sacrifice the future for the present. (This is like killing the goose that lays the golden eggs.)

"The shaving system was not again practised in 1886." We can let the subject now rest. Those who have read what has been recorded will need no further comments, for they can judge for themselves. We were right when we expressed in 1878 our opinion that this system could not possibly have a satisfactory commercial result. It is against nature to repeatedly injure the plantation and to impair the normal growth of the trees.

Influence of shaving on original bark.

1893. To ascertain if the shaving method could influence the value of the original bark above the shaved portion, 25 trees were

shaved to about $1\frac{1}{2}$ metres above ground, and at the same time a strip of bark was taken from the higher portion which had not been shaved, and analysed. Three months later new pieces of bark were cut from 10 trees and analysed, and 5 months afterwards pieces from the remaining 15 trees were cut in such a manner as to leave a small space between each cutting alongside the place of the old sample, and these were analysed. After this interval a comparatively important decrease of alkaloid was observed. The average reduction in the first ten analyses was 0·16 per cent., and in the 15 others was 0·34 per cent. of quinine. The decrease in the different specimens was, however, not equal, it was in some cases very little—·02, and in other cases much—to ·9; this was probably due to the degree of injury done to the trees by shaving.

SHAVING AND RENEWING.

1903. To close 1903 we shall record the final paragraph which contains a sharp criticism on the "shaving method." Four analyses of diseased trees of original Ledgeriana (37 years old) are worthy of remark. The branch bark contains more quinine than the stem-bark in consequence of the excessive cork-formation in the latter, mainly due to the mode of harvesting adopted in the preceding year; stem-bark 4·05, renewed bark 4·65, branch-bark 4·45, and root-bark 3·25 per cent.

Excessive cork formation on old Ledgers due to previous shaving lowers value of bark.

Grafting.

In 1866 on the premises of the *pässangrahan* at Tjinjirocan, the experiment was tried to engraft the inferior Calisaya on Pahudiana by means of slip-grafting. In 1873 these trees looked promising; the graft and the trees were completely united. Moens next experimented to see if the tree and graft reciprocally influenced the alkaloid content and his investigations had a striking result which he records in these words. "This test appears to support the idea that the nature of the alkaloid in barks of different species is dependent on the peculiar tissue of the bark of each species and that the leaves do not influence it."

GRAFTING commenced in 1866.

"When much later the grafting of the high quality Ledger on succirubra was generally adopted it has many times been confirmed as Moens has said that there is an improvement of the succirubra stock."

Reciprocal influence of graft and stock.

1873. The report shows trials with grafting in the open air (commenced by Ottolander in the nurseries with great success) gave poor results. And in the report for 1883 it is said: "The experiments of grafting on succirubras in the field gave persistently

GRAFTING.

such bad results that they were stopped altogether." (For a long while grafting was practised successfully not only in nurseries but also on plants in the field.)

Experiments on alkaloidal transference.

In 1882, "some analyses of grafted trees showed a comparatively high content of cinchonidine giving rise to fear that the succirubra stem influenced the Ledger graft. The quinine content of the succirubra stem was also a little higher than usual, indicating again a mutual influence of scion and stock. Other tests, however, removed this fear as it was explained that the shoots of cinchonidine-bearing trees had been used. In future scions will be used from trees not containing cinchonidine."

In 1885, "in order to certify what influence the succirubra stem has on the composition of the bark of the Ledger shoot which has been grafted on it, the shavings of the bark were submitted to analysis. In the shavings as well as the strips of bark of the 5-year old grafts of Nos. 73 and 89, an important percentage of cinchonidine was detected, amounting to 3·30 and 1·40 per cent. respectively."

The parent trees contained respectively:—

——	Quinine.	Cinchonidine.	Quinidine.	Cinchonine.	Amorphous.	Total.
In 1876-1881	10·59	...	...	0·31	·43	11·33
17	9·79	...	·05	0·55	·56	10·95
„ 1877-1881	10·79	...	...	0·23	·51	11·53
89	11·20	1·17	...	0·57	·45	13·39

"On the strength of these results," says van Leersum, "the influence of the succirubra stem on the composition of the bark of the grafted Ledger cannot be denied." The bark of a shoot, grafted on the well known parent tree No. 23, was analysed and gave also 1·11 per cent. of cinchonidine, whilst the bark of the parent tree gave in two analyses:

——	Quinine.	Cinchonidine.	Quinidine.	Cinchonine.	Amorphous.	Total.
In 1874 .	9·97	...	...	traces.	1·90	11·17
„ 1881 .	11·01	...	...	·59	·13	11·73

Transformation of alkaloids proved.

It appears that all these analyses confirm the hypothesis that in the living tree transformation of alkaloids takes place. The mutual comparison of the parent trees Nos. 23, 73 and 98, discussed above,

seems to indicate this. For without the influence of a succirubra stock, there appeared cinchonidine in No. 89, and if more such comparative determinations had been made it is very probable that more surprising results would have been obtained. GRAFTING.

In 1886, investigations on the influence of the succirubra stem on the Ledger graft were continued.

"It appeared from the analyses that this influence is most distinct in the lower part of the graft while it decreases at $\frac{1}{4}$ metre ($9\frac{3}{4}$ inches) above the junction and entirely disappears at $\frac{1}{2}$ a metre ($19\frac{1}{2}$ inches). The high cinchonidine percentage (1·54—2·77) in the bark of the parent tree No. 73 remains inexplicable, unless it may be taken for granted that in the bark of the parent tree that died in 1882, cinchonidine was present notwithstanding that analysis showed that it was not." **Cinchonidine appears where not expected but need not surprise us.**

It is our opinion that there was no justifiable reason for surprise seeing that deviations had so often occurred and the almost certain fact that transformation of alkaloid in the living tree takes place, that even the transformation of other alkaloids might precede that of quinine and that this quinine might again be transformed in its turn.

"The stronger growth by which grafts distinguish themselves from seedlings and shoots, caused by a sound succirubra stock, justifies the continuation of artificial multiplication which ensures the rearing of very rich specimens." **Excellence of succirubra as a stock.**

This explanation, comprising as it does the principles of grafting, signifies particularly that a harmful influence of the succirubra stock on the graft is not to be feared. But more is said on this subject: "On the ground of chemical research it might therefore be accepted that the influence of the succirubra stock on the composition of the bark of the Ledger grafted thereon is only detected in the lowest part of the graft."

1891. Upon analyses of grafts of the descendants richest in quinine of the parent trees Nos. 23 and 38, the 28 analyses made gave extraordinarily good results. Most of the flowering specimens had, however, to be rejected for seed purposes; since for the laying out of seed plantations, only those plants can be taken which in addition to a high quinine content in the bark are satisfactory in every respect, *viz.*, habit, leaf and flower.

In 1898, the suspicion of Moens that the cinchonidine of the succirubra stock is transferred to the grafted Ledger was found to be correct from experiments carried on in 1885-86, but a continued study of this point revealed the fact that the quinine of the **Influence of succirubra stock on Ledger graft proved.**

GRAFTING.

root bark of grafts is so much higher than that of succirubras not-grafted, and it was proved by a number of analyses (18) that this is due to the grafting of Ledgers which causes a part of the quinine to be transferred to the stock, and the higher the quinine content is in the Ledger the greater increase is noticed in the succirubra stem. If moreover stable manure is applied, and the alkaloid in the Ledger is increased, the succirubra stock also shows an increase in amount.

Moens had made investigations in the same direction in 1873 and 1881, he then having no suspicion that there might be an important influence to the disadvantage of the graft, but reckoning if the game is worth the candle, and taking into consideration that the purpose of grafting is "to get vigorous growth," we came up against the fact that when the rich Ledger will not thrive by its own roots, its being grafted on quick and strong growing trees will ensure success.

Robusta will serve as stock as well as succirubra.

In 1906, it has already been pointed out that the grafting and growth of Ledger on the hybrid Robusta is not inferior to that of the succirubra.

Influence of Seasons.

SEASONAL INFLUENCE.

In 1898, "sixteen analyses were made with the object of discovering in what manner if any the season influences the alkaloidal content of the bark. For this purpose the bark of a good many trees were cut at the beginning of each quarter, and these investigations will be kept up for some time. Moens made similar experiments in 1875."

In 1899, the experiments were continued and thirty-two more analyses were made on the problem of weather conditions influencing the alkaloids. From the results it appeared that 6 of the 8 trial trees had slightly decreased in the course of the year while only two showed a small increase of 0·1 to 2 per cent. of quinine. As abnormal weather conditions, such as a long drought or heavy monsoon, will probably have the greatest influence on these results, the experiments will have to be continued for some time longer before it can be settled in which season the bark is richest.

"The results, however, indicate that it is of little or no importance in which season the barks are collected and that no change will be caused in the actual time of harvesting which is in the east monsoon. During the rainy season the bark more easily peels from the tree and great care is taken in factories supplied with proper arrangements for drying the bark during the damp period."

1901. The investigations regarding the influence of the weather on the quantity of alkaloid were continued and it was accepted with certainty that as far as experiments went, "the season has not the slightest influence on the alkaloidal content, . . . and that any month of the year could be fixed for the purpose of harvesting the Ledger bark."

INFLUENCE OF SEASON.

Harvest may be made at any season without bark being affected.

Aspect.

In 1903, "two analyses were made of barks of grafts growing on the Tjikembang estate. Those on the northern slope of one mountain range contained 7 per cent. of quinine sulphate, and those on the southern slope 8·45 per cent. Analyses of the soil will have to settle if this great difference is due to the different character of the soil or to the prevailing winds on the northern slope causing the trees to look more slender than those on the southern slope." Evidently a further explanation is wanted as to the cause of this difference, and the suggestion was offered that it should be made between the eastern and western slopes.

SOUTHERN ASPECT BETTER THAN A NORTHERN ONE.

In the next year Dr. Viëtor Sibinga tried to explain by comparative soil analyses the variation noticed in the plants growing at Tjikembang. The investigation which is described in detail certainly affords little differences in the percentages of fertilising elements, with the exception of magnesia which on the south and north slope on the upper and lower land respectively contain $\frac{2 \cdot 03}{1 \cdot 86}$ and $\frac{1 \cdot 31}{0 \cdot 78}$ per cent. To these slight variations the difference in the alkaloidal content of the garden on the north and south slopes could hardly be ascribed. It would be better to consider the difference in the physical condition of the soils. Dr. Nanninga while investigating the influence of the soil on the composition of the tea-leaf, discovered that very porous lands are poor in manganese while land less porous contain much manganese. Sibinga found in the upper and lower soils of the north slope 0·48 and 0·70 per cent. of manganese oxide as against 0·29 and 0·33 in the soil of the south slope. Probably the greater exposure of the north slope to winds is of greater influence and may be the likely cause.

Difference apparently not due to soil.

Influence of Removing Branches.

In 1890, six analyses were made for the purpose of discovering whether the removing of branches influences the composition of the bark. For this purpose immediately under the branch of the tree on which the experiment was to be made a strip of bark was taken.

REMOVING BRANCHES UNFAVOURABLY INFLUENCES THE BARK.

INFLUENCE OF REMOVING BRANCHES.

Then the branch was removed. A month after the operation another strip of bark was taken. The analyses showed that the removal of the branches, which are vigorous and not stunted, has an unfavourable influence on the composition of the bark.

Influence unfavourable.

Before and after the removal of the branches the figures for quinine were successively 7·81—7·69, 8·26—7·96 and 10·62—10·10, and those of the total alkaloid were 11·56—11·32, 11·90—11·73 and 11·90—11·40. Four of these trees were very rich in cinchonidine, while in one it decreased from 1·74 to 1·72.

1893. Experiments were repeated this year with the same results.

System not recommended.

In 1894, "the experiment was repeated in order to discover if after more than a month the unfavourable influence may be felt. The barks were examined five months after the removal of the branches. It was found that there was no unfavourable influence; but although this removal according to the result of the analyses showed no disadvantages, similar treatment is not to be recommended, because besides other consequences, the further development of the tree is arrested for some time."

Soils and Manuring.

SOILS AND MANURING.

In 1892, "an experiment was made with artificial manure in a garden at Soekawana of ten-year old Ledger cuttings. These cuttings were planted in 1881 and were half shaved in 1889. The shaving was not repeated. The manure mixture consisted of hornmeal, bonemeal, saltpetre and iron sulphate; 62½ kg. of this manure were mixed with 315 kg. rice bran (dèdèk). On a square Roe (=32·8 sq. ft.) 1 kg. of manure was used, *i.e.*, with 165½ grammes of salts and 834½ gr. of bran. The mixture was strewn round the tree and worked under with a spade. The trees stood at a distance of about 1 sq. Roe."

Experiment with artificial manure.

"The manuring took place on the 15th January 1892, and at the same time the bark of 100 trees was analysed. The second analysis took place on the 1st September 1892, that is about 8 months after. For this purpose out of each tree a strip of bark was cut for the first analysis of about 15 c. m. long and 1 c. m. wide at a height of 1·5 m. above the ground, while for the second analysis, a strip was cut alongside the first incision of the same dimensions. In order to be quite sure, duplicate analyses were made, the results of which corresponded with each other, showing

SOILS AND MANURING.

that the unmanured as well as the manured trees had increased about 0·5 per cent. in quinine." Evidently the working of the manure has been of too short a duration.

We have recorded this experiment in full to show that there were and are cinchona planters who spare neither pains nor expense to profit by scientific help and knowledge. The experimenter was Mr. von Winning, the first to place, in 1875, his own land under Cinchona at Djajagiri, and who since has not slackened in his zeal, being an interested party in another concern. The experiments did not seem to be quite satisfactory as far as can be judged from the report. Three years ago more extensive and costly experiments were started on another private estate. The growth of the cinchona was in this garden generally slow and the quinine percentage had much deteriorated after some years.

In a systematic manner samples of soils were taken from the best and worst portions of ground and examined physically and chemically in Waaiganingen in Holland, with such conscientiousness and expert knowledge as it is customary to devote to such undertakings. The results, however, could afford little or no light on the question as to "what was the cause of the deterioration," and whether it could be attributed to a want of phosphoric acid in the bad soil.

No improvement in one year.

"In concert with scientific workers, comparative experiments with manures were planned and strictly carried out to see if phosphate and Chili-saltpetre (sodium nitrate) serve for the manuring of the soil in order to improve it, and they were so planned that should the method prove remarkable the results could not escape observation. It was also worked out how the influence of the iron already in the soil could be exercised on the added superphosphate, and with that object in view lime was added to the experimental plots some months before. Prior also to the experiment, pieces of bark were cut from the trees, and this was repeated in the same manner and at the same height a year afterwards. The analyses did not show the least difference in a year's time, notwithstanding the manure, and even in growth no improvement was observed."

Does this prove the uselessness of the manure? Not at all. The plantations were patiently observed; and it is possible that future analysis will show a good return. One should always remember De Gasper's time-honoured warning that in agriculture things must be proved before one allows oneself to embark on a new course on a large scale.

SOILS AND MANURING.

1895. A collective analysis is given in this report. One hundred trees were manured with cattle manure in the month of September 1894. After six months the influence of this was plainly observed. The trees standing on the manured strip not only acquired more leaf, but the foliage had turned to a dark green—a thing which made them prominent among the other non-manured trees which they resembled before the manuring took place.

Nitrogenous manure improves the plants.

It is not surprising that manuring, especially with material particularly containing nitrogen, stimulates a plantation quickly; and this can be accepted as a rule. It would, however, have been important in this case if the investigation at the same time showed how far the bark improved, although one analysis points this out. The manured trees had not decreased in alkaloid percentage, so it is stated, while the unmanured trees had.

Experiments with stable manure.

1896. "In continuation of previous investigations, 27 analyses were made to discover the influence of using stable manure. For this purpose some strips of land of two gardens planted with the grafts from Nos. 23 and 38, in August 1895, were manured with a mixture of stable manure and compost. After the manure had done its work for eight months, the barks were analysed, but they did not show any difference in the amount of alkaloid. This may be due to the short time the trees had the benefit of the manure. Had the time been longer there would have been a difference of about 1 per cent. quinine, which is proved by nine analyses of barks of trees which had been manured a year and a half before."

Duration of influence of manures.

Was a conclusion justifiable here? Were other causes considered impossible? The report goes on to say further:—"More and lasting experiments are to be made to settle the question whether by a longer action of manure the alkaloid percentage continues to increase, or if after the action is exhausted the quinine content again returns to its normal figure, *i.e.*, whether the influence is only temporary or not."

Treatment of the ground by manuring and tilling and the nature of the soil are certainly considered to affect not only the growth but also the alkaloidal content, and there is nothing wonderful that it should be so. But these are factors to be considered when rules are to be framed regarding the so-called age limit. (See De Indische Mercuur, Oct. 15th, 1907.)

A comparative experiment with cherry laurel plants.

Concerning the influence of manure, particularly of nitrogen, it may be of use to recall here an experiment in 1892-93, by Dr. J. DeGroot who was of opinion that by a suitable manuring of our

medicinal plants their active substances may be steadily increased and regulated. For trial objects, six shrubs of **Prunus laurocerasus** —the leaves of which when distilled make the cherry laurel water —were used. These six shrubs stood close to each other. In the beginning of 1893 five of them were manured with Wagner's "gardendunger salz," a mixture of phosphate of ammonia, calcium nitrate, sodium nitrate and sulphate of ammonia. Two of the five received the addition of saltpetre, and the 6th got nothing. In October the leaves of all were gathered in three separate lots; Nos. 1 and 2 yielded 0·950 kg. leaf, Nos. 3, 4 and 5, 1·435 kg., and No. 6, 0·530 kg. The average crop of the shrubs did not differ much. The three lots yielded respectively 1250, 1250 and 655 c. m. l.* of distillate. Calculated per 1 kg. of leaf, that would be respectively 871, 884 and 1,235 c. m. l. The prussic acid content appeared in the two manured series to be 35 and 48 per cent. higher than in the unmanured. Although the experimenter did not fix either a rule or law, the surprising result seems to confirm the preliminary opinion. Though we do not assert that saltpetre cannot also be transformed into quinine in cinchona cultivation, an experiment mentioned before did not show any signs of it. Further experiments are recommended.

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Experiments with cherry laurel.

1897. "It had been already shown by previous analyses that the difference in the physical and chemical nature of the soil bears the greatest influence on the alkaloid percentage, and this is proved by 21 further analyses," the results of which range from 5·03 to 11·05 per cent. of quinine.

"The trees examined all stood in the middle of terraces 4 Rynlandsche feet broad (1 Rh. foot = 12·36 English inches) and equidistant from each other, while the nature of the surface and subsoil was uniform. In course of terracing the garden, the soil of the upper terrace had come to be the richest, and by reason of this, those trees planted on the upper terraces proved to be the best, and had a much higher yield than those on the lower terraces. With the object of ascertaining if a heavy treatment with a manure holding much nitrogen could bring about an improvement in the alkaloid content in the trees in a poorer soil, these, after a control analysis of the bark had been made, received a liberal supply of stall manure.

Attempt by means of manure at improving a garden.

"These manure experiments must not be stopped too soon, and should be tried in many gardens, because, as it appears from the

* Cubic millilitre.

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abnormal results of 20 analyses, there is no trace of the influence of stable manure on the Ledger bark contents even after 18 months; while the analyses of hybrid grafts which are given in Nos. 150-170 show, as compared with the above analyses on Ledger bark, an increase (in the hybrids) of as much as 1 to 2 per cent. sulphate of quinine."

"Analyses Nos. 141-181, concerning an experiment to be detailed in a future report whereby it is hoped that in well manuring some strips of land alongside unmanured strips to find an explanation for phenomena hitherto obscure; in addition to horse and cow manure, experiments will be made with artificial manures. The reporter was supplied free of cost with 1,000 kilos. powdered phosphate, 800 kilos. blood meal, and 800 kilos. potassium chloride, for use in the Government cinchona plantations. The results cannot be published till later, together with those of analyses Nos. 182-190, which relate to manuring with sulphate of ammonia carried out by the manager of the Daradjat estate."

"Much more remains to be investigated. Growth and richness of alkaloid must depend on other factors, and for an exact comparison it would certainly be desirable if more were known about the nature of the ground. Soil analyses may have a considerable value, as a guide."

According to 15 analyses the increase of the percentage in gardens which had been purposely treated only superficially, amounted in a year to 0·9 per cent. while this figure was nearly doubled (1·6 per cent. quinine) when the ground was properly attended to. Four analyses show that the alkaloidal content is changed by more or less deep tilling, with or without green manure. One recognises that the soil so responds to better working not only in the matter of production, but also in the alkaloids.

1898. "Seventy-five analyses showed that stable manure and compost had a very favourable influence on the quinine content of Ledgers as well as of hybrids, in the first place on the quinine and in the second place on the total alkaloids. It should, however, not be forgotten that only from a much greater number of analyses, definite figures on this difficult manuring subject can be obtained, therefore the data must be regarded as preliminary. This is also the case with the unsolved problem that after manuring the quinine remains constant in some cases, and in others, under similar circumstances, it shows an enormous increase."

Manuring of grafts.

"Moreover no success had yet been attained in an attempt to increase by means of manuring the contents of the bark of grafts

which for some reason had not come up to the standard of the mother trees from which they had been taken. The mode of manuring, the kind of manure used, whether it is old or new, etc., and the nature of the soil, and the weather, may all influence the growth."

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Artificial versus stable manure.

The experiments with artificial manure have already been recorded in the foregoing report. Before the manure was applied, 66 analyses were made. After one year the results will be communicated. From the private estate at Daradjat, with its peculiar soil, some figures can however be recorded (49 analyses of Nos. 25, 30, 23 and 23^3 gave from 5·02 to 9·53 per cent. of sulphate of quinine), but on the land stall manure and compost gave the best results, while, when sulphate of ammonia was used, a decrease in the percentage was noticed.

Green manure.

1899. The experiments with the rearing of Lupines in the cinchona plantations gave unexpected results. Lupines are out of place in shaded ground, and those which were grown in old gardens, appeared to form small nodules containing little or no nitrogen. More favourable results were observed in young gardens where, after repeated interplanting, the quinine percentage of the strips treated with green manure, appeared to have risen 1 per cent. as against only 0·5 per cent. in the unmanured strips. There was also observed the objection that Lupines grow less willingly in repeatedly tilled ground, as the cinchona grows better.

"In order, therefore, to increase the quantity of nitrogen and the phosphoric acid, (which is often hard to dissolve and which lies deep seated), and the potash, the 1-3-year old gardens and those reserved for 2nd or 3rd plantings and uprooted gardens, will, in future, before being used for replanting, be sown with Lupines for a few times and these worked into the soil."

My opinion is that this treatment is the most rational. It has been practised for years in the Daradjat estate until the late Mr. Doorman had the impression that the restoration by manuring the soil with oil-cake could be adopted at a small expense. It would be difficult to adopt any general rule, but I would certainly plant Lupines for a few times in uprooted gardens before using that garden for another cinchona crop, as it would give the soil a rest and would improve its physical condition.

Slow action of manures.

"Concerning the experiments with artificial manures which were spoken of in the foregoing report, it appears from comparative analyses that a year after manuring not the least increase in quinine was observed: (this was exactly as it was at Daradjat, *vide*

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report of 1898), while on the contrary the strips of trees manured with 2·5 kilos. cowdung and compost per tree showed an increase of 0·5 per cent."

With these manuring experiments which, as sufficiently proved, do not ensure immediate remarkable results, the economical problem should be taken into consideration: *e.g.*, expenses of manuring, transport and labour may be relatively high.

A successful experiment.

"When the surface was covered with stable manure and compost in gardens having very scanty soil, the plants in bad leaf and a yellow tint predominating, within six months, as a result, the trees not only acquired dark green leaves, but the composition of the bark had gained 1 per cent. in sulphate of quinine (see analyses 209-10 of material of the Tjikembang estate which was examined —one six months after the other, and showed before and after the operation respectively 4·89 and 5·93 per cent)."

Expenses of manuring.

Regarding the expenses of manuring. "The stall manure treatment is not only very expensive but it can only be applied to a small area, as there are only a few cattle and these are generally at a great distance. Moreover, owing to the want of proper cemented and covered dungpits, the conditions are not as they should be from an agricultural point of view. The tendency which cowdung has to form into tough lumps to the exclusion of water and air, hinders the decomposition, and these lumps sometimes remain for years. The great variations in the results obtained by the investigation of trees being manured with cowdung must be partially ascribed to this faulty manuring."

"As the same cultivation is continually carried on on the same ground, the same chemical elements are being extracted from the surface soil, and other materials have to be found."

Use of castor oil-cake.

"By frequent and deep tilling, this obstacle has partially been removed; but eventually the soil must lose its properties. It remains an important question to find a substance which would not only be easily procurable but of little expense. The substance has been found in a well known common plant of the Euphorbia family, namely **Ricinus spectabilis,** Blume, (**R. communis,** Linn.) in the shape of the residue which is left after the oil has been extracted and what is known in Java as "boengkil djarak kaliki" (castor oil-cake). An estimation of the nitrogen in this manure made at Tirtasari showed that it contained 6·7. Another sample from elsewhere only contained 5·46 per cent."

The manuring problem is justly considered of great importance to the planter. When the cultivation was started on virgin soil,

carefully chosen by Junghuhn, manuring was for many years unnecessary. Although considerable local differences in the nature of the soil sometimes occurred especially in volcanic districts, the land was on the whole sufficiently rich in humus and in mineral nutritive substances, having been covered with virgin forests for ages. It appears to us that with a reasonable cultivation, coupled with a careful tilling of the ground, there need not be any fear, in consequence of the harvesting of the bark, in the near future, for what is usually called "exhaustion of the soil." The proof of the correctness of this remark will be seen when the report of 1904 is taken in hand. It must be further remarked that in our volcanic soil the larger part of the material is in its virgin state, and is therefore not fit to nourish plants at once. This also partly explains the useful effect of proper ground tilling which stimulates the soil. SOILS AND MANURING.

"Experience demonstrates that the residue of the pressed seeds of the ground-nut **(Arachis species)** makes in many cases an excellent manure, a fact which has been known for ten years in the cultivation of sugar-cane. If with a great influence on the growth of the cinchona, an increase of quinine could be ensured, it would then serve as the most beneficial measure for the culture. Use of ground-nut cake.

"For manuring, $2\frac{1}{2}$ kg. were used per tree, and within the short space of six months the yellow tint of the plantations had not only totally disappeared, but a deep green had taken its place and the trees had made so much leaf that it became necessary to thin them. In three trial trees, the quinine percentage in the bark had risen to 0·86, 0·96 and 0·82 per cent. Another trial tree with 5 kilos. per tree, showed for the same period an increase of only 0·60 sulphate of quinine."

1900. "Two important questions concerning the manuring and the location of the alkaloids came very near to solution. Not less than 153 analyses were made on the manuring."

"Broughton's experiences of manuring in the Nilgiri Cinchona Plantations must now be mentioned, and I quote here the following:—'Using for one tree 0·1 to 0·45 kg. of manure consisting of sulphate ammonia and Peruvian guano, he found that after two years the alkaloid percentage had much increased, compared with similar non-manured gardens, although no difference in growth was noticeable between the trees. Succirubra benefited much by sulphate of ammonia, and the officinalis by guano, so much so that the latter contained after the experiment nearly double the amount Experiments with manures on the Nilgiris.

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of quinine which was present before the manuring.' (In the meantime however the trees had grown two years older.)"

"Trials with stall manure gave also good results as Broughton found that after 5 years (the trees were manured every six months for 2 years) an increase of 2·40 to 7·10 per cent. had taken place. Generally speaking, stable manure is better than artificial manure."

Stall manure in Java.

"In Java, gardens which were progressing slowly were manured with stall manure for some time, and the investigations in the preceding year led to fairly the same results as in British India. But as had been noted in former reports many obstacles were attached to the application of stall manure, therefore trials with all kinds of artificial manure as a substitute were made, but none was found to satisfy the combined demands of cheapness and usefulness. A statement appended shows sufficiently how little was the satisfaction obtained."

Green manures.

"Only green manure of Lupines (doubtless also other leguminous plants) are recommended, but for young plantations only as they do not thrive very well on shaded land, and the nodules containing nitrogen do not develop sufficiently."

Oil-cake the best manure.

"As had been noted in the former report, oil-cake proved to be the long desired substance, the egg of Columbus, as the reporter says." Although the intense green tint and the growth denote the favourable and quick influence of this manure, this is not always the case with the alkaloidal improvement, for only after a year sometimes the first traces of it are noticed, but then it takes place gradually and surely, and the effect only lasts two years."

"The use of oil-cake as a manure in cinchona gardens brought about such state of affairs as a natural consequence that the prices went up enormously. The Government estate thought it, therefore, expedient to plant the borders of their grounds with **Ricinus,** and press out the oil from it, which would perhaps find a ready consumption by the State Railway, thereby attaining the double aim of economy and utility.

Duration of influence.

1901. "As was noted in former reports an increase of alkaloid can be noticed 12 months after the soil has been treated with oil-cake, and the figures show that this increase reaches its highest value after two years, when it remains stationary."

It is obvious that more data are required for explanation, as the question of maturity has already been mentioned, and it is not made clear whether or not manuring modifies this rule of the age

limit. It has been accepted that after the fifth year the increase of quinine stops, and a gradual decrease of alkaloid commences; it has to be decided if this arrest and decrease can be modified by manuring and deep tilling.

"In all the trials with castor oil-cake $2\frac{1}{2}$ kg. were used per tree"; the trials for six months to reduce this quantity to 1 kg. gave as the preliminary result that after that period a higher proportion of 0·73 per cent. was found, against about 0·80 per cent. when $2\frac{1}{2}$ kg. were used per tree. It is not said whether it is better to use the lesser quantity.

Castor oil-cake a satisfactory manure.

"The abovementioned planter wrote also:—'The results obtained here with oil-cake are very satisfactory. This oil-cake had 7 per cent. nitrogen and cost over fl. 6 a pikol.* I gave the plants which had been placed in old dug-up gardens 2×60 grammes per tree, but did not note the results of the increase in alkaloid. The growth and strength of the trees have, however, much improved. It would doubtless have been better had not those frequent heavy rains lessened the useful effect of the oil-cake. It is striking that the gardens here, after applying oil-cake, are always attacked by caterpillars and Helopeltis. The neighbouring unmanured gardens, on the contrary, suffered very little.'"

Relative value of oil cake and chemical manures.

The results of the trials with the chemical manures from Rotterdam mentioned in the foregoing report, did not turn out unfavourable, but they are far behind oil-cake and are more expensive, but the increasing demand for oil-cake threatened to make it also too expensive, and it was decided to start the growing of **Ricinus** plants on grounds not required for cinchona. After two years of experience, however, that method of home-growing had to be abandoned. Obstacles cropped up which caused the continuance to be impracticable, and moreover it appeared in the meantime that great quantities of castor seed could be bought from the people and an unlimited market could be found for the oil in the Government Railway. With the old crushing and pressing installation the profits were already so considerable that the oil-cake for one's own use was calculated at only 42 cents a pikol. The abundance of oil-cake made stall manure superfluous, and luckily so as this manure attracts the larvæ (koe-oeks) which chiefly breed on the young roots of the cinchona plants, destroy them, and cause them to die. Stall manure, it is said, should only be used in old gardens. I may mention here that in my time, *i.e.*, before 1876,

* Pikol or pecul = 135·63 lb. Av.

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much trouble was caused by these larvæ in Lembang on unmanured grounds. As soon as a young plant began to wither, the ground round all the young plants was dug up—an action which facilitated the destruction of the larvæ. The land had served for years as pasture for buffaloes, and it is possible that the manure left behind by them still attracted the vermin.

Effect lasts for three years.

1902. "It appears from the results obtained last year from the experiments with castor oil-cake that even after three years the favourable effect was still noticeable, so much so that the amount of quinine had increased from 6·87 per cent. before the manuring to 8 per cent. after 2 years, and it was 7·86 per cent. after 3 years—which is still higher than originally."

One kilo per tree sufficient.

"In the former report it was already noted that the quantity of 2·5 kg. per tree was reduced to 1 kg., and it was proved that this was quite sufficient, as the amount of quinine increased in six months from 5·09 to 5·82, and in one year to 6·22 per cent."

"As the reduction in manure does not cause a considerable decrease in the percentage, and being an important economy, it was generally adopted in 1902, and has continued ever since."

"Taking into consideration that the greatest part of the Government plantations since 1854 has had the same plants under cultivation it must be agreed that manuring has become a *sine quâ non* condition."

Why the plantations did not need manure in the early years.

Readers of this explanation should be enlightened on the subject of the history of the Government plantations. From 1854 to 1864 no forest timber had been cut for the founding of cinchona gardens; all the cinchona was planted in the original virgin forests. From the hundreds of thousands of trees thus placed, hardly any came to perfection, a result which however could not be expected. About the middle of 1864 forest clearing was started for the formation of regular plantations. Till about 1866 this clearing was only partially done, and the best tall forest trees were left, as it was thought that the entire clearing would not be advisable since the big trees would act as a sort of a protection from the sun to the young plants. In 1866, the removal of all the trees had become necessary, because they could not resist the strong spring and autumn gales, and their uprootal caused considerable damage to the plantation.

The value of weeds as manur e

Till 1875, 900 bouws *in toto* were cleared for cinchona, and this took place gradually according to a system that was described in the report of 1865, and which justified the hope that exhaustion of the ground need not be feared in the near future. Loss of fertile soil was avoided as much as possible, and all refuse in the gardens

was buried. It was noticed that the weed which thrived abundantly was the Composite "Sintron" **(Erechtites valerianifolia,** DC.), and this was cut and allowed to remain on the ground to be dug into the earth when the tilling took place every one or two years. When this loss was prevented as much as possible, an improvement of the soil took place by the regular burying of green or dry matter.

On the land which was cleared and planted for the first time in 1865, the so-called original Ledgers occur at present (1907)—that is after 40 years, and a comparative chemical investigation of that and the virgin soil, carried out in 1904 by Dr. Sibinga, proved that it had not deteriorated.

Planting distance curtailed: its effect on soil.

About the year 1880 the planting distance between each tree was curtailed, and this gave the cultivation an altogether different aspect and outturn, with the addition of an unmistakable influence on the soil.

"The experiences and decisions on the mixed manure from the chemical works at Rotterdam, which were discussed in the former reports, were found to be the same, except that although not inferior to castor oil-cake, it is preferable to it on account of its being cheaper and working quicker."

Oil-cake and caterpillar.

"The statement of a private planter which was quoted in the foregoing report with reference to oil-cake being an attraction to caterpillars and Helopeltis is quite in opposition to the experience obtained on the Government estate. With the latter it was found that the unmanured plantations, on account of their having less stamina, suffered most from those pests, whereas if the soil had sufficient nutriment by the application of oil-cake manure, it would act as a panacea. A striking example of this was a young graft-garden in Tirtasarie, with poor soil where the 2-year old plants suffered seriously from Helopeltis, so that they remained backward and began to languish, but as soon as the oil-cake was applied, and the ground thoroughly tilled, the plants after a few weeks sprouted out vigorously, so much so that after four months this garden was not recognisable."

Effect of manure declines after four years.

1903. "Thirty-six analyses show that four years after manuring with oil-cake the effect begins to decline. In one case there was a marked decrease from 7·86 per cent. in the third year to 6·19 per cent. of quinine in the fourth year. This enormous reduction was however due to the heavy flowering of the trees in 1903, as a consequence of the violent east monsoon in 1902." This explana-

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tion may be accepted, but again it has been forgotten that "many factors influence the action of the manure, such as quantity, time of manuring, weather, mode of application, not to speak of condition of the soil." It has been noticed that bats' guano acts less quickly than oil-cake, judging from the appearance of the trees.

1904. "Sixty analyses concern the experiments with different kinds of manure. For this purpose were employed: bats' dung, dark and light green ground-nut and kapok oil-cake, with a nitrogen content respectively of 7·9, 5·05, 7·50 and 5·48. With the first (bats' dung) the experiment was made in eight gardens, and in all of them an increase of quinine was obtained, an average of 0·5 per cent. The price of this manure—analysed in detail by Dr. Sibinga—was fl. 3·50 per pikol; each tree was given one pound, and the advantage from it amply repaid the expenses incurred."

"In a garden where the trees had been given 2 lbs. instead of 1 lb. of bats' dung, a decrease of 0·45 per cent. was observed; probably an increase will take place after some time. The same results happened with the trees which had been manured with the three other kinds mentioned; after six months a decrease was observed in most cases, but after 12 months there was an increase. The expense of these manures was amply compensated by the higher quinine content of the bark."

Tilling.

TILLING.

1898. "To repudiate the opinion of some planters that the land in which cinchona is planted requires hardly any tilling, experiments of former years bearing on this subject were continued. Twenty-six alkaloidal determinations were made in plantations which were intensively tilled, breaking the surface, and not tilled at all. The results were beyond doubt."

Its benefit to the land.

1899. "Another series of analyses was made to illustrate the influence of tilling. In gardens which had been spade dug (patjoel) with green manure, the alkaloid had risen 2 and $2\frac{1}{2}$ per cent., those having surface tilling (mapas) 0·7 to 1 per cent., while in undisturbed land (babad) only 0·5 per cent. increase was shown over that of the year before.

1900. "Forty-seven analyses again indicated the good influence of tilling the land in the increased yield of quinine."

Diseased Trees.

Importance of removing diseased trees.

1891. "Five analyses showed the great importance of at once rooting out trees which are attacked by root disease and stem

kanker, and harvesting the bark. The average percentage of quinine and total alkaloid was:— DISEASED TREES.

From sound root bark of 5 trees	.	.	.	6·71 and 10·26
„ diseased „ 5 „	.	.	.	4·87 „ 7·77
„ dead „ 4 „	.	.	.	2·69 „ 4·37

In a diseased and sound trunk bark there was found respectively 7·33, 9·49 and 5·74—7·97 in the total.

1894. "Two analyses proved that the amount of quinine in diseased specimens not only decreases, but quite a different proportion between the alkaloids is created, so that the removal of diseased trees must always be the first consideration." Decrease in alkaloids noted.

1899. "Four analyses of about 34-year old original but diseased Ledger trees showed 5·74 per cent. of quinine in the trunk bark, 5·82 in renewed bark, 4·95 in branch bark and 4·78 in root bark.

Drying the Bark.

1879. "Earlier investigations showed that the bark cut in strips does not suffer from drying in the sun, but the question remained, whether the barks scraped off in chips or shavings would endure this drying without damaging the alkaloid, especially as regards the percentage of quinine. A series of experiments made in 1879 exhibited so slight a variation that the sun drying of chips even was not to be feared. This result is certainly of importance, as the possible influence of the direct sunlight on the action of the living tree had often been discussed that it was desirable to know how it affected the harvested bark." Effect of drying bark on proportion of alkaloid.

1887. The question, "to what temperature may cinchona bark be exposed for drying purposes" was answered by the following experiments:—"A temperature of 105°C. may be reached without risk, but at a temperature of 110°C. a slight difference in the alkaloid is detected, while this decrease becomes greater by drying at 115°C. The barks used for the experiment were first dried in the sun, and then exposed for 24 hours to temperatures of 70-120°." Drying at 105° is safe.

1888. "It appears from 12 analyses that the bark when exposed to a temperature of 105°, *immediately* after harvesting, does not contain much less alkaloid than when it is dried in the sun. The maximum temperature prescribed for artificial drying is for the sake of safety fixed at 95°." Maximum temperature prescribed is 95°C.

The word *immediately* has been printed in italics with a reason, because it offers great risks. It is known that the green bark is not dried in the form of powdered bark but in coarse pieces and in

DRYING THE BARK.

strips, and the risk is that the thorough drying of those pieces is impeded by the strong heat applied immediately after gathering, which causes the outside to contract, thereby preventing the inside from being thoroughly dried. In Lembang it was once found with fresh tobacco leaves that in drying the fresh leaves very quickly, the tobacco when baled became mouldy, for the simple reason that the inside of the leaves which retained a green colour was not properly freed from moisture.

1894. Experiments were again made to observe the possible influence of artificial drying on the alkaloidal content of succirubra as pharmaceutical bark. "As appears from the results, the application of artificial heat of 200° F (93°C.), as has already been stated, has no unfavourable influence on the alkaloids either of succirubra or Ledgeriana bark."

100°C. for artificial drying.

1902. "Ten years ago the reporter tried to find out up to what temperature it is possible for Cinchona bark to be dried without danger of the alkaloids decomposing, and he came to the conclusion that for all artificial dry installations, whether Sirocco or plate-oven, the heat should not exceed 100°C. (or 212°F.). In the past year (1901) the experiments were continued to solve the question if by drying with artificial means there is a difference between the bark thus dried and the bark that comes fresh from the garden."

"It appeared without any exception that no loss in content took place, when fresh green bark was dried at once at a temperature of 50—60—70°C. Only at 80° there was a decrease of 0·23 per cent. quinine, and at 90° of 0·41 per cent. quinine, while the freshly cut sample dried at 100°C. yielded a percentage of 7·86. The same sample after being first dried in the air and then at an artificial temperature of 100° C., gave as a result 8·47 per cent. against 8·45 per cent. of the control number dried in the open air."

"The investigations are being continued, but from those described it appears that a preliminary drying in the sun is necessary, because freshly harvested bark goes back (in quality) at a temperature of 80° C."

It seems important to draw attention to the fact that drying in the sun and drying artificially are not the same. In the latter case the chance is that the quick contraction of the outside layers more or less prevents the inside from being thoroughly dried.

Preliminary drying in the sun or air recommended.

1903. "The experiments on the best method of drying the bark were continued, and the results still showed that a pre-

liminary drying in the sun is necessary, and after that not to exceed about 70°C. (or 160°F.) in the Sirocco. For example—and this is from double analyses which were made for the sake of accuracy—bark dried in the air contained 6·79 per cent., while the same bark when immediately dried for 21 hours at 100°C. only contained 4·12 per cent., showing that it had decreased 2·67 per cent. in quinine." Comparing these striking results with the many recorded in previous years it is difficult not to suspect some mistake.

DRYING THE BARK.

"When however the bark was first dried in the air for 3×24 hours, and after that at 100°C. for 3×8 hours, this decrease was less, *viz.*, from 8·30 dried in the air, to 7·55 first in the air and then at 100°C., a decrease of 0·75 per cent." The thickness of the bark is also an important factor, for thin bark loses at 100°C. more in proportion than thicker bark, because the latter dries slower.

If the freshly gathered bark is brought at once to the Sirocco, and the drying takes place gradually, the influence of the light can be left out of reckoning, and the risk of loss in alkaloid will be restricted as much as possible. Without an increase of temperature there cannot be complete drying, but it should not pass the limit: for incomplete drying which does not reach to the interior of the bark can, must indeed, have bad consequences.

Tannin.

TANNIN.

High in succirubra bark.

An important investigation is noticed at the end of the report for 1898, *viz.*, the amount of tannin in Cinchona bark. The presence of this substance, which occurs largely in Cinchona, makes the bark valuable for the manufacture of the well-known febrifuge, "China Liquida," a preparation discovered by Dr. J. E. DeVrij, and made on a large scale by J. J. Vernet, Apothecary at Tiel. "The results of Vernet's investigation concerning the quino-tannates of 30 trees are compiled in a separate table, and it appears that the percentage ranges from 4·0 to 23·7 in the bark. The reporter adds that it need not be mentioned that the propagating of tree No. 110 which gives the latter high figure will be carried out. This is also of great importance to cinchona planters, as the price paid for similar succirubra bark is double of that paid for succirubra containing less tannin. Thus in February 1898 a consignment of succirubra bark with 20 per cent. of quino-tannates realized 55 cents per $\frac{1}{2}$ kilo, while another lot which was not in-

TANNIN.

ferior in alkaloidal contents, but yielded 12 per cent. of quino-tannates realised only 28 cents."

Tannin, a factor in fixing price of bark.

"The quantity of total alkaloid and the appearance of the bark as well as the percentage of quino-tannates will in future be factors in fixing the prices of succirubra barks." This announcement must have been appreciated by those interested, for it is known that the bark for manufacturing purposes is prepared to be sent in the form of chips. Although the alkaloidal determinations were often surprising, the determination of the tannates met with more serious difficulties. According to a supplement of the report for 1898 the highest and lowest prices realised for succirubra bark at the February sales were 46½ and 25 cents. Evidently there must have been a mistake somewhere. No mention is made of the tannate percentage of the barks put up for sale.

Quinetum.

QUINETUM: Mixed alkaloids of the bark.

Through the advice of Dr. De Vrij a large quantity of fresh succirubra bark was given to his pupil Eydman, a Military apothecary, to convert it, according to a process of DeVrij, into coarse mixed alkaloids called "Quinetum." Mr. Eydman reported in January 1874 that he was unable to discover any method of economically manufacturing quinetum from the fresh bark. The dry bark supplied a good looking preparation of sufficient purity; but there was much loss, 308 kilos of bark, containing 20·3 kilos of alkaloids, yielded only 10·3 kilos of quinetum.

A good febrifuge.

Therapeutic tests of this quinetum showed that it is a good febrifuge and that it could replace sulphate of quinine in many cases. A great drawback however was that quinetum was of variable composition, and for this reason it would not inspire confidence among physicians. At the close of 1877 it had not been decided whether it was desirable to make quinetum in the East Indies, and if it was, the question where and how the work could be carried out had to be settled.

This discussion which caused much discontent and strife has long since lost its interest, since there is an abundance of quinine available, the therapeutic value of which is undoubted. Yet this episode in the quinine cultivation of Java in 1876-78 was of great importance as it threatened to become a danger to the enterprise.

Succirubra bark only suitable for quinetum.

Through the influence of Dr. De Vrij in the mother country it was proposed to send out Mr. Eydman as a Chemist to the Govern-

ment plantations and as manufacturer of quinetum; the growing of succirubra trees as of first importance was impressed upon him. It is known that Dr. De Vrij preferred this species above all others, and he expected the most salutary results from it. This conviction he strongly held until the end. Mr. Moens, however, was of a different opinion altogether, and he was supported in his objections by van Gorkom. Mr. Eydman on his arrival was found some suitable employment in the sugar industry, and the experiments of making quinetum were conducted in the Government laboratory at Wetarreden by Mr. Hokmeyer. The quinetum question was thus satisfactorily disposed of.

QUINETUM.

Quinium.

QUINIUM: A preparation of crude alkaloids.

In 1885, a request was made by the private Cinchona planters to His Excellency the Governor-General to ascertain the practicability of exporting the crude alkaloids with the object of saving the expense of packing and transporting the worthless fibre of the bark. An experiment was made in the laboratory at Bandoeng with 10 kilos of bark containing over 6 per cent. of alkaloid. By boiling with lime and alcohol, a preparation of so-called quinium was obtained which appeared to contain about 60 per cent. of alkaloids, and the bark was practically exhausted. Quinium differed from quinetum in that the latter was introduced as a substitute for quinine, then too expensive for general consumption, while the former was offered to manufacturers in place of the bulky raw material. To solve the question of the utility of the quinium it was resolved to send it to Holland for opinion. Samples were distributed to the quinine factories at Amsterdam, Brunswick, Frankfort, Feuerbach near Stuttgart and London. Reports were duly submitted, from which it was gathered that the venture on the whole was received with disfavour. The chief objections were that the alkaloids were variable in composition; five factory analyses showing from 13·8 to 23·5 per cent. of quinine alkaloid in the product; and it would be very uncertain whether the bulk would correspond with the sample. With regard to the saving in freight it was argued that with the freight so very low it would be more profitable for the manufacturer to import good bark than a crude preparation. It was also stated that the manufacture of quinine from this resinous substance was not much easier than manufacturing from the bark, so that in this case the work done in Java was practically wasted. Calculated on the quinine basis on the con-

Samples examined in Europe.

QUINIUM.

tinent, then at 5 pence per unit, it was found that the cost of the bark itself would be higher than the quinium prepared from it, so that absolutely nothing was left for the manufacturing processes in Java. It was remarked that several years ago an attempt was made in South America, where the freight is higher, to export an extract of the bark, and the owner not being able to obtain his price for the substance, it was sold after 4 or 5 years without reserve. As far as Java was concerned the attempt was not encouraging and no further experiments were made.

Attempted manufacture abandoned.

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(Vegetable Product Series, No. 116.)

THE AGRICULTURAL LEDGER,

1911-12—No. 5.

OILS AND FATS OF INDIA.

OILS and FATS of VEGETABLE ORIGIN produced in BRITISH INDIA, by DAVID HOOPER, F.C.S., F.L.S.

INTRODUCTION.

The object of this Ledger is to bring together general and technical information on the sources, properties, uses and value of vegetable fats and oils available in India. The records of the office of the Reporter on Economic Products to the Government of India have been consulted, and a large number of samples of oils and oil seeds, forwarded to the Indian Museum by officers of the Forest and Agricultural Departments, have been tested in the chemical laboratory. This compendium, it is hoped, will serve as a guide to merchants in giving information on the distribution of raw materials, and enable the analyst to recognise genuine and adulterated oils in the local markets. Several oils of minor importance are noticed, not only for their scientific interest, but also as possible sources of future commercial attention. Frequent references have been made to the invaluable work of Dr. Lewkowitsch on "The Technology and Analysis of Oils, Fats and Waxes," and the book should be consulted by those desiring further acquaintance with the technical side of the subject. Acknowledgment must be made of the use of the analyses of Indian oils by Drs.

Crossley and Le Sueur in 1898, and those by Mr. A. Kasava-Menon in 1910, besides the work of other investigators.

The trade in Indian oils and oil seeds is one of increasing importance. In 1906-07 the value of the exports of oil seeds was Rs. 12,82,97,037; in 1910-11 it reached Rs. 24,79,81,759. Giving priority to the larger exports, these were linseed, rape, sesamum, ground-nut, cotton, castor, poppy, mowra, niger, mustard and tea. In 1906-07 the value of oils exported was Rs. 46,77,307; in 1910-11 it reached Rs. 71,02,015. The oils, arranged according to importance, were coconut, castor, linseed, mustard or rape, sesamum and ground-nut. During the corresponding period of five years the import of oil seeds into India have remained almost stationary, while the imports of vegetable oils have slightly increased. References to the trade will be found under the respective names of the raw materials.

The oils are discussed under the botanical names of the plants yielding them, which is considered more satisfactory than employing the common or vernacular names. The arrangement of the raw materials according to their natural orders has the further advantage of collecting these widely-distributed products under a scientific classification without imparing, it is hoped, the usefulness of the Ledger to the merchant and manufacturer.

VEGETABLE OILS.

(*Arranged botanically.*)

RANUNCULACEÆ.

Nigella sativa, Linn.

MENISPERMACEÆ.

Anamirta Cocculus, W. & A.

PAPAVERACEÆ.

Argemone mexicana, Linn.
Papaver somniferum, Linn.

CRUCIFERÆ.

Brassica spp.
Diplotaxis Griffithii, Hk. f. & T.
Eruca sativa, Lamk.
Lepidium sativum, Linn.

CRUCIFERÆ—*contd.*

Raphanus sativus, Linn.

CAPPARIDEÆ.

Capparis grandis, Linn.
Cleome viscosa, Linn.
Cynandropsis pentaphylla, DC.

BIXINEÆ.

Cochlospermum Gossypium, DC.
Flacourtia Cataphracta, Roxb.
Cynocardia odorata, Br.
Hydnocarpus Wightiana, Bl.
Taraktogenos Kurzii, King.

GUTTIFERÆ.

Calophyllum Inophyllum, Linn.
Calophyllum Wightianum, Wall.
Garcinia Cambogia, Desr.
Garcinia Morella, Desr.
Garcinia indica, Choisy.
Garcinia Mangostana, Linn.
Mesua ferrea, Linn.

TERNSTRŒMIACEÆ.

Camellia Thea, Link.

DIPTEROCARPEÆ.

Shorea robusta, Gaertn.
Vateria indica, Linn.

MALVACEÆ.

Bombax malabaricum, DC.
Eriodendron anfractuosum, DC.
Gossypium spp.
Hibiscus cannabinus, Linn.
Thespesia populnea, Corr.

STERCULIACEÆ.

Heritiera littoralis, Dryand.
Sterculia fœtida, Linn.

LINACEÆ.

Linum usitatissimum, Linn.

GERANIACEÆ.

Impatiens Balsamina, Linn.

SIMARUBACEÆ.

Balanites Roxburghii, Planch.
Samadera Indica, Gaertn.

BURSERACEÆ.

Canarium commune, Linn.

MELIACEÆ.

Amoora Rohituka, W. & A.
Carapa moluccensis, Lamk.
Melia Azadirachta, Linn.

CELASTRINEÆ.

Celastrus paniculatus, Willd.

SAPINDACEÆ.

Sapindus trifoliatus, Linn.
Schleichera trijuga, Willd.

ANACARDIACEÆ.

Anacardium occidentale, Linn.
Buchanania latifolia, Roxb.
Mangifera indica, Linn.
Pistacia vera, Linn.
Semecarpus Anacardium, Linn. f.

MORINGEÆ.

Moringa pterygosperma, Grtn.

CONNARACEÆ.

Connarus nitidus, Roxb.

LEGUMINOSÆ.

Arachis hypogæa, Linn.
Butea frondosa, Roxb.
Cæsalpinia digyna, Rottl.
Glycine hispida, Maxim.
Pithecolobium dulce, Benth.
Pongamia glabra, Vent.
Psoralia corylifolia, Linn.
Dalbergia cultrata, Grah.
Dalbergia Sissoo, Roxb.

LEGUMINOSÆ—*contd.*

Tamarindus indica, Linn.
Xylia dolabriformis, Benth.
Acacia concinna, DC.
Ormosia tavoyana, nov. sp.
Psophocarpus tetragonolobus, DC.

ROSACEÆ.

Cydonia vulgaris, Pers.
Prinsepia utilis, Royle.
Prunus Amygdalus, Stokes.
Prunus Armeniaca, Linn.
Prunus communis, Huds.
Prunus persica, Stokes.
Prunus Puddum, Roxb.

COMBRETACEÆ.

Terminalia Catappa, Linn.
Terminalia belerica, Roxb.
Terminalia Chebula, Retz.

LYTHRACEÆ.

Lawsonia alba, Lamk.

CUCURBITACEÆ.

Citrullus Colocynthis, Schrad.
Cucumis sativus, Linn.
Cucurbita maxima, Duchesne.
Luffa acutangula, Roxb.
Luffa ægyptiaca, Mill.

UMBELLIFERÆ.

Daucus Carota, Linn.

CORNACEÆ.

Cornus sanguinea, Linn.

CAPRIFOLIACEÆ.

Viburnum coriaceum, Blume.

COMPOSITÆ.

Carthamus tinctorius, Linn.
Carthamus Oxyacantha, Bieb.
Guizotia abyssinica, Cass.
Helianthus annuus, Linn.
Vernonia anthelmintica, Willd.

SAPOTACEÆ.

Bassia butyracea, Roxb.
Bassia latifolia, Roxb.
Bassia longifolia, Linn.
Dichopsis obovata, Clarke.
Mimusops Elengi, Linn.
Mimusops hexandra, Roxb.
Payena oleifera, nov. sp.

EBENACEÆ.

Diospyros Embryopteris, Pers.

OLEACEÆ.

Olea cuspidata, Wall.

SALVADORACEÆ.

Salvadora oleoides, Dcne.

APOCYNACEÆ.

Cerbera Odollam, Gaertn.
Nerium odorum, Soland.
Thevetia neriifolia, Juss.

LOGANIACEÆ.

Strychnos Nux-vomica, Linn.

SOLANACEÆ.

Datura Stramonium, Linn.
Nicotiana Tabacum, Linn.
Hyoscyamus niger, Linn.

PEDALINEÆ.

Sesamum indicum, DC.

LABIATÆ.

Origanum vulgare, Linn.
Perilla ocimoides, Linn.

AMARANTACEÆ.

Celosia argentea, Linn.

CHENOPODIACEÆ.

Spinacia oleracea, Linn.

MYRISTICEÆ.

Myristica canarica, Bedd.
Myristica malabarica, Lamk.

LAURINEÆ.

Actinodaphne Hookeri, Meissn.
Litsæa Stocksii, Hk. f.
Litsæa zeylanica, Nees.

EUPHORBIACEÆ.

Aleurites moluccana, Willd.
Chrozophora verbascifolia, A. Juss.
Croton Tiglium, Linn.
Croton oblongifolius, Roxb.

EUPHORBIACEÆ—*contd.*

Euphorbia dracunculoides, Lamk.
Jatropha Curcas, Linn.
Jatropha glandulifera, Roxb.
Putranjiva Roxburghii, Wall.
Ricinus communis, Linn.
Sapium indicum, Willd.
Sapium sebiferum, Roxb.

URTICACEÆ.

Cannabis sativa, Linn.

JUGLANDEÆ.

Juglans regia, Linn.

CONIFERÆ.

Pinus Gerardiana, Wall.

PALMÆ.

Areca Catechu, Linn.
Cocos nucifera, Linn.

GRAMINEÆ.

Oryza sativa, Linn.

RANUNCULACEÆ.

Nigella sativa, Linn.

The Small Fennel or Black Cummin is cultivated in Mediterranean countries and in India. Vern.—*Kalajira, mugrela,* Hind.; *Siyah daneh,* Pers.

The black seeds are used for medicinal and culinary purposes and occasionally an oil is expressed. The seeds contain 37 per cent. of fixed oil (Greenish); the Erythrean seed yields 32·7 per cent. (Suzzi).

A sample examined by Crossley and Le Sueur (1898) had the following constants: Specific gravity at 15·5° C., 0·9248; saponification value, 196·4; iodine value, 116·2; Reichert-Meissl value, 5·4; butyro-refractometer, 58·5 at 49°. Suzzi found the Maumené test to be 89, the solidifying point of the insoluble fatty acids to be – 19 to – 16, and their neutralisation value 197·6. The sample examined by Crossley and Le Sueur had an acid value of 97·4 and yielded 88·8 per cent. insoluble acids. The high acidity of the sample may explain the apparently abnormal Reichert-Meissl value and the low percentage of insoluble acids. The oil does not dry, and the comparatively high iodine value is probably due to an aromatic compound, as the fresh oil possesses an aroma of eucalyptus.

MENISPERMACEÆ.

Anamirta Cocculus, W. & A.

Cocculus indicus berries or "Coque du Levant" are obtained from this large climbing shrub, and they are known to be poisonous to birds, beasts and fish. The seeds afford, besides picrotoxin, the poisonous principle, a white solid fat.

Schmidt and Roemer (1884) separated 39 per cent. of a fatty acid which was recognised as stearic acid. A sample in the Indian Museum received from Madras under the Tamil name "Kakkai-kolli ennai" (oil of the crow-killer) consisted of a white fat melting at 40°. Its specific gravity at 20° was ·9258; iodine value 42·36. The fatty acids melted at 54°.

PAPAVERACEÆ.

Argemone mexicana, Linn.

The Mexican Poppy or Gamboge Thistle is an American weed naturalized all over India. The small, round, pitted seeds yield an average of 37 per cent. of orange-coloured oil. By ordinary pressure the seed yields from 25 to 30 per cent. of oil, a quantity equal to that obtained from rape seed.

Constants: Specific gravity at 15·5°, 0·9247; saponification value, 190·3; iodine value, 119·9 to 122·5; insoluble fat acids and unsaponi- [illegible] 95·07, melting at 22° (Crossley and Le Sueur). The oil gives with nitric acid an orange-red colour. It dries to a hard jelly,

gaining during the process 8 per cent. in weight, an amount which corresponds with that absorbed by poppy seed oil.

The oil is used for burning in lamps, and is employed by painters as a drying oil and for giving a shining appearance to wood. It is probable, too, that the acridity will prevent the attacks of white-ants and borers. The oil readily saponifies and gives a hard soap with soda. The seeds and oil are acrid and purgative. (*Agricultural Ledger*, No. 5 of 1907.)

Papaver somniferum, Linn.

Poppy seed oil is obtained from the black and white varieties of the opium poppy. The plant is grown extensively in India, Asia Minor, Persia, Egypt and South Russia. The seeds yield from 45 to 50 per cent. of oil. Leather obtained 47·75 per cent. as the average yield in seeds from the United Provinces. The Indian seed which is mostly white, and only rarely red, gives 36 to 38 per cent. in the oil mill, while the Levant seeds, which are white, grey, blue or red, give on a large scale 39 to 40 per cent.

Poppy seed oil has little or no odour and a pleasant taste; it is used as a salad oil, and for the preparation of fine paints for artists. The cake, resulting as a by-product, is rich in nitrogen and, when not mouldy, is fed to cattle.

The constants of the oil have been found to be: Specific gravity at 15°, 0·924 to 0·927; solidifying point – 18°; saponification value, 189 to 197·7; iodine value, 132·6 to 157·5 (Indian 153·48, Levantine 157·52, Utz.); Reichert-Meissl value, 0·00; Maumené test, 86—88·5. Insoluble fatty acids, per cent. 94·9; specific gravity at 100°, 0·888; melting point, 20°—21°; neutralisation value, 199; iodine value, 139.

It is probable that palmitic acid is the only solid fatty acid present. According to Hazura and Grüssner the liquid fatty acids consist of 5 per cent. of linolenic acid, 65 per cent. of linolic acid and about 30 per cent. of oleic acid.

Poppy seed oil is occasionally contaminated with small quantities of sesame oil, owing to the seed being usually expressed in the same works where sesame oil is produced. The adulterant is detected by the lower iodine absorption of the sample and by the characteristic Baudouin colour reaction (see **Sesamum indicum**). When fraudulently added to olive oil it is recognised by the higher iodine value and specific gravity.

CRUCIFERÆ.

Brassica spp.

Lieutenant-Colonel D. Prain (*Agricultural Ledger*, No. 1 of 1898) has arranged the mustards of Bengal according to the following classification:—

Brassica oleracea, Linn. Cabbage group.

B. campestris, Linn. Rape or Colza group.

B. campestris var. sarson. Indian Colza.

B. Napus, Linn. Rape group.

B. Napus var. oleifera. Lutni or Tora of Bengal.

B. Rapa, Linn. var. esculenta. Turnip.

B. juncea, H. f. & T. Rai group.

B. juncea var. oleifera. Rai.

Dealing with mustard as an agricultural crop, with reference to the appearance of the seeds and their oil contents, Dr. Leather has arrived at the following classification:—

Yellow Sarson **(B. campestris** var **sarson)** from the United Provinces is the heaviest of the Brassica seeds; weight ·43 to ·68 per 100 seeds, and oil 44 to 49 per cent.

Red and slaty kinds—

(*a*) Sarshaf or Toria of Punjab; slaty brown or dark red; weight ·2 to ·4, oil 37 to 45 per cent.

(*b*) Sarson kali from the United Provinces, similar in size but redder coloured; weight ·3 to ·5, oil 39 to 46 per cent.

Rai of Punjab; smaller seeds weighing ·07 to ·15, oil 27 to 37 per cent.

Desi rai of the United Provinces, similar to above.

Mustard oil is of great importance in India, since it is the chief oil used in cookery and is largely used to anoint the body. Although several varieties of Brassica seeds enter into its preparation, the pure oil is very uniform in its characters. Crossley and Le Sueur (1898) found the oils of Indian mustards to have the following constants: Specific gravity at 15·5° C., 0·914 to 0·918; acid value, 1·4 to 7·3; saponification value, 171 to 180; iodine value, 96·2 to 108; Reichert-Meissl value, ·00 to ·89; insoluble fatty

acids, 94·5 to 96·3 per cent. They belong to the class of semi-drying oils.

Messrs. D. Waldie & Co. specially expressed some pure seed of the yellow Indian Colza **(B. campestris** var. **sarson)** and Rape **(B. Napus),** to ascertain if any difference existed between the oils. The constants were for Colza: Specific gravity 0·9132, saponification value 174·15, iodine value 98·3; and for rape: Specific gravity ·9144, saponification value 174·67, and iodine value 98·2. Examinations of the oils of cauliflower and turnip seeds from Cawnpore showed that they also had similar values.

The uniformity in the characters of pure mustard oils is so pronounced that in the chemical laboratory of the Corporation of Calcutta the following constants have been fixed for the standard of pure samples: Specific gravity at 100° C., 0·894—0·895, saponification number 169—174, iodine value (Wijs) 96—100.

Kinzel has investigated the proportion of essential oil of mustard in Indian species of Brassica, and gives the average yield of tori seed as 0·549, rai 0·814, and sarson 0·708 per cent. The pungency of Indian mustard is therefore not very different from that of European. (*Agricultural Ledger*, No. 7 of 1901.)

Enormous quantities of rape and mustard seed are exported from India. The average of the exports of rape seed during the five years ending in 1910-11 was 5,011,872 cwts., valued at Rs. 3,70,03,278. The mustard trade is smaller, but shows a great improvement, the average amount during the last five years being 56,546 cwts., valued at Rs. 7,47,974.

The traffic in mustard and rape oils also shows a steady expansion. In 1899-1900, the exports stood at 259,661 gallons, valued at Rs. 3,52,962; during the five years ending in 1910-11 the average annual exports were 277,468 gallons, valued at Rs. 4,79,112. The bulk of the mustard oil is exported from Calcutta.

Diplotaxis Griffithii, H. f. & T.

In 1901, the seeds of the above plant were sent to the Indian Museum from Jhelum, Punjab, as an oil seed. They yielded to ether 29·4 per cent. of a yellow oil.

Eruca sativa, Lamk.

This oil seed is grown in Sind, Rajputana and the Punjab, and is exported largely from Karachi. It is known as *jamba*,

jambho, and *tara mira*. In Sind it is the commonest of the mustard tribe cultivated, and the seeds, oil and cake are in greater demand than other products of this class. Compared with Sareh **(Brassica Napus)** the prices per maund are as follows:—

	Seed.		Oil.		Cake.	
	Rs.	A.	Rs.	A.	Rs.	A.
Jambho . .	3	12	13	8	3	4
Sareh . .	4	7	16	0	3	0

According to Leather, specimens of seeds from the United Provinces contain appreciably more oil (34 per cent.) than those from the Punjab (30 per cent.).

The colour of the oil varies from yellow to pale brown, and sometimes has a flavour of turnip. Crossley and Le Sueur obtained the following figures in an examination of authentic samples: Specific gravity at 15·5°, ·915—·917; saponification value, 169—174; iodine value, 97·4—99·7; Reichert-Meissl value, 0·11—0·77. This is a non-drying oil; in other respects it resembles that of **Brassica campestris.**

Lepidium sativum, Linn.

Garden Cress (*Halim*, Beng. and Dec.) is cultivated throughout India. The seeds yield about 25 per cent. of an oil of an orange colour and a faint odour of mustard. Crossley and Le Sueur found the following constants: Specific gravity at 15·5°, ·9221; acid value, 4·18; saponification value, 183·1; iodine value, 118·4; Reichert-Meissl value, 0·22; insoluble fatty acids, 95·57. It belongs to the class of semi-drying oils.

Raphanus sativus, Linn.

Radish seed (*Muli*, Hind.) is occasionally expressed for oil and is said to contain from 45 to 50 per cent. A sample prepared in Sylhet, Assam, had a light-brown colour and a distinct acrid flavour. Crossley and Le Sueur found it to have the following characters: Specific gravity at 15·5°, 0·9163; acid value, 14·47; saponification value, 173·8; iodine value, 92·85; Reichert-Meissl value, 0·33. Insoluble fatty acids, 95·94. This is a non-drying oil.

CAPPARIDEÆ.

Cynandropsis pentaphylla, DC.

The seeds of this wild plant (*Hure,* Hind.) yield a thick, greenish, drying oil. Ether extracts 25 per cent. of this oil having the following values: Acid value 6·4, saponification value 194·6, iodine value 119·5.

Cleome viscosa, Linn.

The seeds of this common weed yield a greenish coloured limpid oil.

Capparis grandis, Linn.

According to the Bombay Gazetteer the seeds of this tree afford an oil which is used in medicine and for burning.

BIXINEÆ.

Cochlospermum Gossypium, DC.

A silk cotton tree occurring commonly in the drier parts of North India. The seeds are kidney-shaped or cochleate, with a hard shell, about $\frac{1}{4}$ to $\frac{1}{16}$ inch long. The kernels have a pleasant, almond-like taste, and are eaten in Celebes.

The oil, which is present in the seed to the extent of 14 to 15 per cent., is rather thick and of a light-brown colour, readily bleaching on exposure to light. It is liquid at ordinary temperatures, solidifying at 1° and having the specific gravity of 0·922 at 15°. The following constants were obtained by S. N. Dey: Acid value 14·24, saponification value 186·29, iodine value 95·97, Reichert-Meissl value ·19, Maumené test 54·5°. The insoluble fatty acid amounted to 95·19 per cent. and melted at 35·5°. The oil appears to occupy an intermediate position between a semi-drying and a non-drying oil. (*Agricultural Ledger,* No. 5 of 1906.)

Flacourtia Cataphracta, Roxb.

The Many-spined Flacourtia or Prunier d'Inde is commonly cultivated, and an oil is said to be extracted on the Malabar Coast

from the seeds. The kernels yield to ether 44 per cent. of a nearly colourless and tasteless oil with slight siccative properties. The seeds mixed with water evolved an odour of hydrocyanic acid.

Gynocardia odorata, R.Br.

A native of Sikkim, Assam, and Chittagong in East Bengal. Up to the year 1900 the seeds of this tree were supposed to be the source of chaulmugra oil of commerce used extensively for leprosy and skin diseases, but in that year it was discovered that the true source was the seed of **Taraktogenos Kurzii.** Chaulmugra oil at the ordinary temperature is a solid (melting point 20°—23°), but the oil of Gynocardia seeds is a liquid. Furthermore, chaulmugra oil is optically active and consists of the glyceryl esters of members of the chaulmoogric acid series, whereas the oil from Gynocardia seeds is optically inactive and contains neither chaulmoogric acid nor its homologues. It is also a drying oil.

Dr. Power and Messrs. Lees and Barrowcliffe have examined the seeds and oil. [*Journ. Chem. Soc.*, LXXXVII (1905), 349 and 896.] The seeds contain a cyanogenetic glucoside, gynocardase.

The oil gave the following values: Specific gravity at 25°, 0·925, 0·929; acid value, 4·9—5; saponification value, 197·0—199·6; iodine value, 152—152·8.

The oil consists of the glyceryl esters of the following acids: (1) Linolic acid or isomerides of the same series, constituting the largest proportion of the oil; (2) palmitic acid, in considerable amount; (3) linolenic and isolinolenic acids, the latter predominating; and (4) oleic acid in relatively small amount.

Hydnocarpus Wightiana, Blume.

A tree indigenous to the Western Peninsula of India. The oil of the seeds has been brought to the notice of Europeans as a substitute for chaulmugra oil, and has been used in Bombay with satisfactory results.

Power and Barrowcliffe [*Journ. Chem. Soc.*, LXXXVII (1905), 884] have examined the seeds. The kernels representing 75 per cent. by weight of the seeds, afforded 32·4 per cent. of oil when subjected to hydraulic pressure. The oil, at the ordinary temperatures, is a soft solid, having a faint yellow colour and a characteristic odour.

It gave the following values: Melting point, 22°—23°; specific gravity at 25°, 0·958; acid value, 3·8—7·4; saponification value, 207; iodine value, 101·3—102·5. This oil closely resembles chaulmugra oil and contains chaulmoogric acid and a lower homologue of the same series.

Hydnocarpus anthelmintica, Pierre.

A tree indigenous to Siam. The seeds are exported to China under the name of *Lukrabo*, and are known in the latter country as *Ta-fung-tsze*.

Power and Barrowcliffe examined these seeds and the results are recorded in the above-mentioned paper communicated to the Chemical Society.

The powdered seeds extracted with ether afforded 17·6 per cent. of oil similar to chaulmugra oil. The values were: Melting point, 23°—25°; specific gravity at 25°, 0·953; acid value, 7·5, 8·1; saponification value, 208, 212; iodine value, 86·4, 82·5. It contained chaulmoogric and hydnocarpic acids and afforded indications of the presence of a cyanogenetic glucoside.

Taraktogenos Kurzii, King.

A large tree found in Eastern Bengal and Assam, Burma and the Andaman Islands. Vern.—*Chaulmugra*, Beng.; *Kalaw-bin* (the tree), *Kalaw-the* (the seeds), Burm.

The seeds have a thick, firm testa; albumen copious, firm; embryo central, straight, with large, cordate, foliaceous, 3-nerved cotyledons. They yield, on expression, 30 per cent. of a thick oil with a peculiar aroma, which constitutes the chaulmugra oil of commerce.

Power and Gornall (1904) obtained the following values: Specific gravity at 25°, 0·951, at 45°, 0·940; optical activity [α] D 15° + 52°; acid value, 23·9; saponification value, 213; iodine value, 103·2.

The oil yielded the following constituents: Chaulmoogric acid, melting point, 68°; palmitic acid; formic and acetic acids, and a small amount of phytosterol, melting point 132°.

The oil-cake contains 3·39 per cent. of nitrogen and 1·8 per cent. of phosphoric acid. (*Leather.*) (See "Chaulmugra seeds of commerce," *Agricultural Ledger*, No. 5 of 1905.)

During recent years "marotti" fat or "cardamom" oil has been offered for sale in the United Kingdom and the Continent, and it was supposed that the oil was expressed from the seeds of some species of Hydnocarpus or chaulmugra. In 1911 it was recorded that several poisoning cases had occurred in Germany through the consumption of margarine made from "marotti" fat. An investigation made at the Hamburg Hygienic Institute showed that this fat is very similar to that yielded by **Hydnocarpus Wightiana** and **H. venenata.** (*Zeitsch. Nähr. und Genuss mittel*, 1911, **22,** 441.) All three fats contain chaulmoogric and hydnocarpic acids, which are now shown to be physiologically active, causing nausea and vomiting and producing irritation of the mucous membrane of the stomach.

GUTTIFERÆ.

Calophyllum Inophyllum, Linn.

A large tree dispersed over a wide area which extends from East Africa through the East Indies to Polynesia. It is commonly referred to in literature as the Alexandrian Laurel. The spherical fruits known variously as Laurel or Domba nuts, or as Udilo or Dilo seeds, weigh about 6·5 grams of which the shell forms 4·5 grams. The dried seeds yielded on extraction with ether 60·4 per cent. of a dark green, feebly drying oil which had an aromatic smell. The green colour is due to the presence of a resin which can be removed by treating the oil with boiling alcohol or by shaking it with a dilute solution of sodium carbonate. After this treatment the oil is of a yellowish-brown colour. The oil-cake contains (Agricultural Department, Bombay) 3·77 per cent. of nitrogen, 1·5 potash, and 1·73 phosphoric anhydride.

The constants of the oil are: Specific gravity at 15°, ·9415; melting point, 7·5°; acid value, 67·5; saponification value, 198·7; iodine value, 95·3; insoluble acids and unsaponifiable, 78·3 (saponifiable resin 18·26 per cent.); unsaponifiable, 0·35; melting point 36·5°; neutralisation value, 192·3; iodine value, 94·8; mean molecular weight, 289. (C. Grimme, *Chem. Rev. Fett.-Ind.*, 1910, **17,** 233-263.) Fendler found this oil to contain palmitin, stearin and olein.

Calophyllum Wightianum, Wall.

This evergreen tree occurs on the Western Ghats from the Konkan to Travancore, and the seeds yield locally a lamp oil

similar to that of the previous species. The kernels contain 72·5 per cent. of a bright yellow oil. Two samples of the oil, examined at the Imperial Institute, gave the following results: Specific gravity at 15·5°, 0·938, 0·940; acid value, 13·0, 27·0; saponification value, 200·3, 199·2; iodine value, 103·0, 79·75; titer test, 19·6°, 31°. A sample of this oil sent to London in 1907 was valued at a little below the current market price of cotton-seed oil.

Garcinia Cambogia, Desr.

Garcinia Morella, Desr.

These two trees, known respectively in the vernacular as "Murga" and "Gurgi," indigenous in Mysore and the jungles of the Western Coast, afford in May and June an abundance of seeds which are expressed for their fat. The semi-solid yellow fat is called "Gamboge butter," and is used like ghee for cooking purposes, for burning, and as a medicine for sprains and injuries. The oils of the seeds are very similar in composition as their constants indicate:—

	Murga.	Gurgi.
Specific gravity at 50°	0·900	0·902
Melting point	37°	33·5°
Acid value	3·49	13·79
Saponification value	198·20	194·74
Iodine value	53·72	55·46
Reichert-Meissl value	0·69	0·62
Per cent. of fatty acids	94·89	95·20
Melting point of	56°	55°
Iodine value	56·36	57·81

The insoluble fatty acids consist chiefly of stearic acid (about 30 per cent.) and oleic acid with a small amount of palmitic acid. The fat is probably composed of oleodistearin. (Hooper. *Journ. Asiatic Society, Bengal*, Vol. VIII, Pt. v, 1907, 257.)

Garcinia Indica, Choisy.

A slender tree found on the ghats of the Konkan and Kanara, considerably cultivated. Vern.—*Kokam*, Hind.; *Ratambi*, Dec.; *Murgala*, Kan.; *Brindao*, Goa. The fat is called Kokum butter. Mangosteen oil, Brindonia Tallow, Huile di Madool.

The fat is prepared on the West Coast in a primitive fashion by drying the seeds in the sun, pounding them and boiling in water. The fat is then skimmed off, filtered in a crude fashion and moulded into round or egg-shaped cakes weighing about 100 grams each. Kokum butter is white or light-grey fat having a slight, not disagreeable, odour and a mild oily taste. It is chiefly used as an edible fat and is employed as a substitute for, or an adulterant of, ghee. It is also used in pharmacy for ointments. When unfit for edible purposes it is worked up for soap.

The fat has the following characters: Specific gravity at 40°, 0·895; melting point, 41° to 45°; saponification value, 186·8 to 191·5; iodine value, 25 to 34; Reichert-Meissl value, 0·11 to 1·54. Insoluble fatty acids and unsaponifiable, 94·5; melting point, 61°; mean molecular weight, 282.

The fat consists chiefly of oleodistearin.

Garcinia Mangostana, Linn.

The mangosteen fruit contains one or two kernels which yielded on extraction with carbon bisulphide 45 per cent. of a highly-coloured fat containing 2 per cent. of unsaponifiable matter. (M. E. Heckel. 1910.)

Mesua ferrea, Linn.

This tree is the Ironwood or Nagkesur of Assam. The seeds, which are like chestnuts, yield 41·6 per cent. of fixed oil, the kernels alone giving 72·9 per cent. The oil is deep yellow or brown, very bitter, and deposits white crystalline fats at ordinary temperatures. The oil-cake contains 24·16 per cent. of protein. (Grimme.)

Three samples from Assam had the following constants: Specific gravity at 50°, 0·9359 to 0·9166; melting points, 26·5° to 16·5°; acid values, 38·4 to 115; saponification values, 203·7 to 205·8; iodine values, 87·0 to 89·1; Reichert-Meissl values, 7·7 to 11·54; fatty acids, 92·2 to 94·1; melting points of 33·5° to 34·5°. The solid fatty acids appear to consist largely of stearic acid. The high acidity and Reichert-Meissl values are noticeable.

Grimme (1910) obtained the following values for this oil: Specific gravity at 20°, 0·9285; solidifying point, 5·5°; iodine value, 82·2; unsaponifiable, 2·51; neutralisation value of fatty acid, 165·3.

TERNSTRŒMIACEÆ.

Camellia Thea, Link.

Tea seed in India is sometimes produced in greater quantity than is needed for planting, and enquiries have been made as to the value and use of the oil and the possibility of obtaining a good manurial material from the residual cake. An attempt was made in 1885 to put tea seed on the London market under the name of "*tanne.*" Great interest was manifested for a time, but the seed found no buyer, and the price asked sank quickly to a level below the cost of importation. The seeds contain from 20 to 25 per cent. of fixed oil, which is clear light yellow, non-drying, approaching olive-oil in its character, but with a more or less acrid taste. The Chiness have long used it for cooking purposes. It answers well for a lamp oil, and it produces an excellent hard and white soap.

The cake left after expression of the oil contains the poisonous constituent saponin, with 1·92 per cent. of nitrogen and 0·58 per cent. of phosphoric acid. The oil-cake is therefore inferior in manurial constituents and would hardly pay for carriage over long distances. Spread on the ground around tea bushes and crops the cake would be likely to keep away certain insect pests.

DIPTEROCARPEÆ.

Shorea robusta, Gaertn.

The seeds of the sal tree are eaten as a famine food in Northern India. According to Professor A. H. Church they contain about 15 per cent. of oil. Mr. O. Reinherz, in 1904, confirmed this result, and remarked that the oil had a small quantity of unsaponifiable matter with an odour of turpentine.

The seeds of **S. Ghysbertiana** and **S. Pinanga,** Scheff., are used as oil seeds in Singapore. They afford, with other seeds, a fat which is known under the generic name of Engkawang or Tengkawang.

Vateria indica, Linn.

The Piney tallow tree of the Western Peninsula. *Dupada*, Tam.

The seeds yield about half their weight of a vegetable fat known as the Piney tallow of Canara or Malabar. The fat is

extracted by grinding the roasted seed and boiling the meal with water; the melted fat rises to the surface and is skimmed off. In a fresh state Malabar tallow has a greenish-yellow colour; on exposure to the air it is rapidly bleached. It has a considerable reputation as a local application to rheumatism, and it might be used as a basis for ointments. It is an edible fat.

Chemical examinations of the fat have been made by Höhnel and Wolfbauer in 1886, and by Crossley and Le Sueur in 1898. The constants obtained were: Specific gravity at 15°, ·915, at 100°, 0·89; melting point, 37°, 42°; saponification value, 188·7, 191·9; iodine value, 37·8, 39·6; Reichert-Meissl value, 0·22, 0·44; melting point of insoluble fatty acids, 56·6°. The fatty acids consisted of oleic acid and 60 per cent. of a solid fatty acid melting at 63·8°.

MALVACEÆ.

Gossypium spp.

One of the features of the Indian oil seed trade has been the rapid increase during the last few years in the exports of cotton seed. In 1898-99 the exports were 1,850 tons, in 1901-02 they rose to 11,250 tons, in 1906-07 to 219,379 tons, and in 1910-11 to 299,011 tons, valued at Rs. 2,29,52,592 (£1,530,172 16*s.*). These large exports represent a small proportion of the amount of seed available, and illustrate the demand there is in Europe for cheap oil-yielding materials. In 1903 cotton seed at Bombay was rated at Rs. 2 4 as. (3*s.* 0*d.*) per cwt. while the wholesale prices of other oil seeds were: linseed Rs. 8 7 as. (11*s.* 3*d.*), ground-nut Rs. 7 2 as. (9*s.* 6*d.*), sesame Rs. 7 (9*s.* 4*d.*) and rape seed Rs. 5 6 as. (7*s.* 2*d.*).

The oil has been estimated in several samples of Indian seeds with the following results: The average of those from the Madras Presidency gave 17·41 per cent., Bombay Presidency 17·66 per cent., Central Provinces 19·65 per cent., and United Provinces 19·89 per cent. The variation in individual samples was small, being from 15 to 21 in extreme cases. The amount of oil contained in Indian seed is much less than in American, which contains upwards of 30 per cent. The Indian seed is also smaller. Specimens of American weighed 12 to 18 grams per 100 seeds, and Egyptian 10 to 11 grams, whilst Indian seed weighed only 5 to 7 grams.

Cotton seed is naturally covered with woolly hairs, and this renders it necessary to remove the husk before the oil is expressed.

Such seeds are decorticated in decorticating machines or "hullers" before crushing, and the kernels or "meats" are separated from the husks by means of another set of machines called "meats and hull separators." Since the husks form 49 per cent. of the seeds and contain only a trace of oil, they leave the kernels with about 39 per cent. of oil which can be expressed with less loss than the undecorticated seeds.

Crude cotton seed oil possesses a ruby-red to almost black colour, due to the seed containing dark brown colouring matter. In order to obtain the yellow refined oil, the acid value is taken, and an amount of caustic soda corresponding to the acid is diluted with water and intimately mixed with the oil while heated to 50°. If a suitable amount of soda has been added the mixture will separate into two layers, the upper layer consisting of decolourised oil, and the lower one forming a dark-brown soap solution or "mucilage." The supernatant oil is drawn off and washed with warm water, when it is ready for use.

In temperate climates cotton seed oil deposits a yellowish-white fat or "stearin" which is separated and the oil is called "demargarinated." "Cotton seed stearin" forms an article of commerce and is largely used in the manufacture of lard and butter substitutes. At the winter temperature of Calcutta (22°—24° C.) very little solid fat is deposited, but by chemical means 29·5 and 32·4 per cent. of stearin were separated from oil obtained from American seed grown at Dharwar. The solid fatty acids consist of palmitic acid and probably small quantities of arachidic acid. The liquid fatty acids seem to consist of oleic and linolic acids only.

Cotton seed oil is typical of a semi-drying oil. Specific gravity at 15°, 0·922 to 0·930; solidifying point, 3°—4°; saponification value, 191—196; iodine value, 106—120; Maumené test, 68 to 78; insoluble fatty acids and unsaponifiable, 95·8 to 96·1; melting point, 35° to 40°; neutralisation value, 201—208; iodine value, 110—115; of liquid fatty acids, 146—149.

Cotton seed oil is readily recognised by the high melting and solidifying points of its fatty acids. There are also certain colour reactions which are employed in analysis. The Halpen colour reaction is one of the best, and is applied as follows: 1 to 3 c.c. of the oil is dissolved in an equal volume of amyl alcohol; to this is added 1 to 3 c.c. of carbon bisulphide holding in solution 1 per cent. of sulphur flowers. The test tube containing the mixture is then immersed in boiling water, and kept therein for some time. The carbon bisulphide evaporates off, and cotton seed oil gives in

the course of five to fifteen minutes a deep red coloration. This reaction is very characteristic, and it is possible to detect thereby 5 per cent., or even less, of cotton seed oil in admixture with other oils and fats.

Confirmation of the presence of this oil may also be obtained by the nitric acid test. This test is best carried out with nitric acid of 1·372 specific gravity. A few c.c. of the sample are shaken energetically with an equal measure of nitric acid, and the sample allowed to stand for some time up to twenty-four hours. Cotton seed oil gives a coffee-brown coloration which is characteristic of this oil to such an extent that admixtures of 10 to 20 per cent. of cotton seed oil to olive oil can be detected in certain cases.

The finer grades of cotton seed oil are used for edible purposes and in the manufacture of margarine. The lower grades are employed in enormous quantities in soap-making. On account of its drying and gumming properties the oil cannot be recommended for lubricating purposes unless it is blown. Smaller quantities of the oil are used in the adulteration of paint oils. The price of refined cotton seed oil was quoted in London (December 1910) at £29 to £32 per ton.

Bombax malabaricum, DC.

Eriodendron anfractuosum, DC.

Under the name of Kapok oil the expressed oil from the seeds of the above silk cotton trees is used. The seeds are about the size of peas and are enclosed in a hard black shell. The oil is expressed on a commercial scale in Holland from material imported from Java; the yield of the oil from the whole seed is 17·8 per cent. on a manufacturing scale whilst by extraction with ether 24·8 per cent. of oil is obtained. The oil is greenish-yellow or reddish coloured and has a great resemblance to cotton seed oil in its properties. Meggitt found 30·75 per cent. of oil in Bombax seeds and 4·52 per cent. of nitrogen. A sample of Semul oil from Bombay had a specific gravity of 0·9178 at 20°, and yielded crystalline fatty acids melting at 41°.

Hibiscus cannabinus, Linn.

The seeds of Ambari or Deccan Hemp, according to the Dictionary of Economic Products, have frequently been sent from India to England as an oil seed. They are said to yield only from 15 to 20

per cent. of oil. In spite of their cheapness they are seldom crushed in this country, but during the past year attention has been paid to their use. The oil is clear and limpid and forms a good lubricating and illuminating material. The seeds yield to ether 22·2 per cent. of oil, having a specific gravity of 0·9255 at 15°. Iodine value 93·1, fatty acids and unsaponifiable 95·66, melting point 33° (another sample 35°), neutralisation value 207·7, iodine value 105·1. The oil afforded 25 per cent. of solid fatty acids melting at 51°.

Hibiscus esculentus, *Linn.*

The seeds yield 16·9 per cent. of oil. (J. Sack.)

Thespesia populnea, *Corr.*

The Portia or Tulip Tree. *Poras-pipal*, Hind. An evergreen tree found in the coast forests of India, Burma and the Pacific Islands. Frequently planted along the roadside. The seeds are small, triangular, a slightly leathery shell enclosing a dark-brown, soft, mealy pulp. The kernels, forming 47 per cent. of the whole seed, yield 41·7 per cent. of a viscid reddish-brown oil. The oil is called "huile amère" and is used locally for cutaneous affections.

Physical and chemical properties.—Fat: Specific gravity at 100°, 0·9018; acid value, 4·81; saponification value, 201·4—204·9; Reichert-Meissl value, 5·9; titration number of insoluble volatile acids $\frac{1}{10}$KOH 0·55, iodine value, 71·5; butyro-refractometer at 25°, 81·5, at 40°, 73. Fatty acids (insoluble) per cent. 95·5; melting point, 43·9; iodine value, 75·3; neutralisation value, 196·9; mean molecular weight, 284·7. (A. K. Menon, 1910.)

STERCULIACEÆ.

Sterculia fœtida, *Linn.*

A tree widely distributed over India and the Malayan Archipelago. The wood has an unpleasant or stinking odour. The seeds are known as Olives of Java, Kalompong beans, Bedingo seeds or Sterculia kernels. The average weight is 2·4 grams. They are formed of an outer parchment-like skin of a violet or purplish colour. Below the skin is a dark fleshy pulp. The kernels are whitish and have a pleasant taste. The seeds yield 34 per cent. of a bland, light yellow, non-drying oil. In Java it is used for culinary purposes and as a burning oil.

The oil has been examined by Wedemeyer in 1906, Bontoux and myself, and the following constants were obtained: Specific gravity at 15°, 0·926, at 30·5°, 0·919; acid value, 6·5; saponification value, 172·4 to 199·3; iodine value, 56·5 to 83·1; Reichert-Meissl value, 0·80. Fatty acids and unsaponifiable, 95·6 per cent.; melting point, 31·5° to 46·5°.

Differences have been noticed between the kernel oil and that extracted from the whole seed. The kernel oil is liquid and slightly viscous. With the Halpen test it gives a cherry red colour. The oil obtained from the whole seed is similar to that of the kernel oil, but deposits white fats at the ordinary temperature. A peculiar property of the whole oil first observed by Wedemeyer is its behaviour on heating to 240°—245° when it is suddenly converted, with spontaneous generation of heat, into an india-rubber like solid substance, no doubt due to a process of polymerisation similar to that of castor oil.

Heritiera littoralis, Dryand.

A small tree of the tidal creeks of Bengal and Burma. Its vernacular term *sundri* is said to have given the name to the Sundarbans. The tree is reported to be the source of an oil in the Antilles. An experiment made in Ceylon in 1908 showed that the oil content of the fruit, dried at 100° C., was 6·9 per cent.; with such a low percentage it is not considered possible to obtain the oil economically.

LINACEÆ.

Linum usitatissimum, Linn.

The importance of linseed as an agricultural crop and oil seed is the fact that the area of production is the third in extent of all other crops, and the value and quantity of the seed exceed those of every other oil seed. The cultivation of linseed has been undertaken since the British occupation. It is grown chiefly in the Central Provinces, Bengal and United Provinces with smaller quantities in Bombay, Punjab and Central India; as a single crop it occupies about 3,000,000 acres and as a mixed crop 500,000 acres. In 1906-07 the exports amounted to 218,941 tons, valued at Rs. 3,25,98,578 (£2,173,238 10*s.* 8*d.*), and in 1910-11 to 370,551 tons, valued at Rs. 8,39,02,377 (£5,593,491 16*s.*). The amount of oil in linseed

is from 37 to 44 per cent., the Central and United Provinces affording a richer seed than that of the Punjab. It was supposed that white seed was better than brown seed as an oil-yielder, but Leather has shown that the colour does not influence the yield. There is not much evidence that the size of the seed is connected with the amount of oil; at the same time all samples of bold seeds contain a high percentage of oil. Experiments made in India with linseed rich in oil, and taken to farms where usually seed yielding a smaller proportion of oil was grown, showed that there was a deterioration.

On cold pressing a golden-yellow coloured oil is obtained having a pleasant taste, so that it can be used as an edible oil. By far the largest quantities of oil are employed in the arts, and in that case the seed is crushed between rollers and heated to about 160° F. in the mixing kettle, and subsequently expressed while still warm. This oil has a yellowish-brown hue and is somewhat turbid, due to traces of moisture and mucilaginous matter. The pressed cake retains about 10 per cent. of oil and is used as a cattle food.

On storing the oil the moisture and mucilaginous matter gradually settle out, and the oil acquires a higher value for technical uses. "Tanked oil" is therefore free from foreign substances. Various methods have been used and patented for refining linseed oil; these embrace the use of such chemicals as sulphuric acid, caustic potash and ozone. Mulder states that linseed oil contains about 10 per cent. of glycerides of solid fatty acids consisting of palmitic and myristic acids in about equal proportions. The liquid fatty acids consist of oleic, linolic, linolenic and isolinolenic acids.

The constants of raw linseed oil as ascertained by various observers are: Specific gravity at 15°, 0·9315 to 0·937; melting point - 16° to - 20°; acid value, 1·2—1·3; saponification value, 190 to 195·2; iodine value, 173 to 190; Maumené test, 103—122; oleo-refractometer degree at 22°, 49 to 54; insoluble fatty acids and unsaponifiable, 94·81—95·5; unsaponifiable, 0·3 to 1·2 per cent.; melting point, 17° to 24°; neutralisation value, 196—198·8; iodine value, 179—209·8; ether insoluble bromides, 30—41·9 per cent. The constants of double boiled oil are: Specific gravity, 0·943 to 0·951; acid value, 4 to 5; saponification value, 190—194; iodine value, 140 to 170; oleo-refractometer degrees at 22°, 62—64.

Linseed oil has a high specific gravity, hence a figure below 0·93 would direct attention to the presence of other vegetable or

mineral oils. With the exception of perilla oil, linseed oil has the highest iodine value of all known oils. Hence the iodine test is the most characteristic one for identifying a sample. Lewkowitsch suggests that if the value of a sample fall below 170 the presumption that it has been adulterated is justified. The bromide test is also important for judging its purity. Pure linseed oil yields up to 38 per cent. of crude ether-insoluble brominated glycerides. Since tung, poppy seed oil, saffiower seed oil, and candle nut oil yield either little or no ether-insoluble bromides, this test readily differentiates between linseed and other drying oils. An important test for judging of the suitability of a linseed oil for making paint oils and varnishes is to heat a few c.c. in a test tube up to 600° F. (315° C.) or until the oil commences to boil. Good oil should remain clear on cooling (as a rule it will become lighter in colour). Impure oils will deposit insoluble matter in this test and are unsuitable for paints and varnishes. Only one mill in India appears to deal exclusively in linseed, namely, that of the Gourepore Company, Limited, near Calcutta. The oil is of standard quality and is supplied to Admiralty depôts in the Far East and Australia.

GERANIACEÆ.

Impatiens Balsamina, Linn.

The minute seeds of this plant, a native of the Punjab, afforded to ether 25 per cent. of a greenish coloured, drying oil. The oil was tested with the following results: Acid value, 10·4; saponification value, 196·8; iodine value, 160. The seeds afforded 3·21 per cent. of nitrogen, equivalent to 20·06 per cent. of proteins. Other species of Indian balsams afford edible seeds from which oil is sometimes expressed and used for burning.

SIMARUBACEÆ.

Balanites Roxburghii, Planch.

This tree is probably a variety of **B. ægyptiaca,** Delile, the Egyptian myrobalan. It is called in India *Hingan* or *Hingol,* and the unripe fruit and bark are used in medicine. The kernels yield to solvents a little more than 50 per cent. of a bland, yellow, tasteless oil, which is applied to burns and sores. The oil has a specific gravity of 0·9185 at 15·5° and congeals at zero. It yields 94·4 per

nt. of crystallized fatty acids melting at 31°, and with a mean mbining weight of 277. It is a slow drying oil and has some ints of resemblance to ground-nut oil.

The Egyptian myrobalan grows in northern tropical Africa here the oil is called Zachun oil. Suzzi (1906) obtained 49·64, d Milliau (1904) 41·2 per cent. of fatty matter from the kernels. zzi published for the Milan Exhibition, 1906, the following aracteristics of the oil: Specific gravity at 15°, 0·92; solidifying int, 0° to 5°; saponification value, 194·1; iodine value, 105·0; aumené test, 75·5. Fatty acids: Solidifying point, 32°—30·5°; utralisation number, 200·0; mean molecular weight, 278·2. The mple gave neither the Halpen nor the Baudouin reaction.

Samadera indica, Gaertn.

A large tree of the Western Coast and Ceylon. *Niepa*, Tam.; *aringhota*, Malabar. Natives extract an oil from the bitter eds which is said to be a good application in rheumatism.

Dr. de Vrij in 1872 expressed from the seeds 33 per cent. of a ght yellow bitter oil which contains according to Oudemans 84 r cent. of olein and 16 per cent. of palmitin and stearin. J. L. B. n der Marck examined the seeds in 1900, and found in them per cent. of fat consisting of 87·7 per cent. of triolein, 8·41 per nt. of tripalmitin, and 3·89 per cent. of tristearin.

BURSERACEÆ.

Canarium commune, Linn.

The tree grows in Penang and is cultivated in Southern India. s Malayan name is Canari or Kanari, and the edible seeds are own as "Java almonds." The seeds are rich in oil, yielding on traction with solvents 65 to 68 per cent., and the oil has a pale llow colour and a pleasant mild taste. The oil was examined ny years ago by Oudemans who found it to consist of 51 per cent. olein and 49 per cent. of stearin and myristin. It has since been amined independently by Wedemeyer and Pastrovich in 1907, e latter of whom found it to be composed of 44·6 per cent. of lmitic and stearic acids, 43 per cent. of oleic acid and 12·5 per nt. of linolic acid. The seeds of **C. oleosum,** Lamk., a tree of pical Asia, were investigated by Grimme in 1910, and the oil ve reactions similar to those of Canari oil.

MELIACEÆ.

Amoora Rohituka, W. & A.

A tree of Northern and Eastern Bengal and Assam, call *Taktaraj, pitraj* and *rana.* An oil is expressed from the seeds aft powdering and boiling in water. The oil is brownish in colo and possesses a slight odour or bitter taste. The following constan have been determined: Specific gravity at 18°, 0·928—0·942; sap nification value, 189·7 to 191·8; iodine value, 91·9 to 134· Hehner value, 93·8; Reichert-Meissl value, 1·16 to 1·64; titer te 30·2°. The drying property of this oil varies. Some samples dri to a skin in three days while others dried very slowly. The oil only used locally.

Carapa moluccensis, Lamk.

A tree of the coasts of Bengal, Malabar and Burma (*Pussu* Beng.). The seeds are said to yield, on expression, a whitish, sem solid fat, used as a hair-oil and for burning purposes. The oil h not been examined, but it is probably similar to that obtained fro **C. guianensis,** Aubl., a common tree throughout tropical Ameri and the West Indies. Carapa or Crab oil is a bitter oil or fat a non-drying nature, and possessing medicinal and insecticid properties. It consists of the glycerides of oleic, palmitic an stearic acids, with a small amount of a bitter principle of an alk loidal nature. (E. H. Gane, 1895; W. H. Deering, 1896. In perial Institute Bulletin, 1908.)

Melia Azadirachta, Linn.

A handsome tree wild or cultivated throughout the greater pa of India or Burma. It is known as Nim in Northern India an Bombay and Veppam in Madras. The seed yields Nim or Margos oil, and, like other parts of the tree, is regarded as a remedial agen The fresh oil has a slight greenish colour, a powerful garlic-li odour and very bitter taste. Warden describes it fully in *Pharm Journ.* [3], XIX (1888), 325. The specific gravity he found to 0·9235 at 15·5°, and at about 10°—7° it congealed without losin its transparency. It deposited a white sediment on standin Warden also found in the oil sulphur, neutral and acid resins, an an alkaloid, besides oleic, lauric and perhaps stearic acid.

Lewkowitsch examined the fat in 1903 with the following esults: It was solid at the ordinary temperature (of Europe); speci- c gravity at 16°, 0·9142, at 40°, 0·9023; saponification value, 96·9; iodine value, 69·6; Reichert-Meissl value, 1·1; refractive ndex (butyro-refractometer at 40°), 52°. The titer test of the nsoluble fatty acids was 42°.

CELASTRINEÆ.

Celastrus paniculatus, Willd.

The seeds of this shrub yield a dark red, pungent oil depositing vhite fats on standing. It is called in India "Malkanguni or Malkagni oil," and in Ceylon "Duhudu oil." It is supposed to be nerve tonic and is given as a brain stimulant to students; it is also pplied externally to sores. The small, red, angular seeds afford 3—44 per cent. of a thick reddish bitter oil.

Samples from Northern India and Burma had the following haracteristics: Specific gravity at 50°, 0·942 to 0·956; acid value, 4·7 to 101·0; saponification value, 218·0 to 246·7; iodine value, 5·5 to 100·8; Reichert-Meissl value, 41 to 42; unsaponifiable matter, ·5. Insoluble fatty acids and unsaponifiable, 70·2 to 86·2; melting oint, 34·5° to 38·5°; neutralisation value, 179·9 to 192·8; iodine alue, 103·1 to 109·3. The fatty acids of the lead salt insoluble in ther amounted to 37 per cent. and melted at 54°. The high saponi- ication and Reichert-Meissl values agree with published analyses f the oil of the Staff tree **(Celastrus Senegalensis)** and Spindle ree **(Euonymus europæus)** of the same natural order.

SAPINDACEÆ.

Sapindus trifoliatus, Linn.

Soapnut tree. *Ritha*, Hind. The seed is the size of a large pea nd is embedded in a fruit the size of a cherry. The kernels form 2·5 per cent. of the entire fruit, and yield an extraction with ether 4·67 per cent. of a semi-solid fat. The expressed oil has a dirty rown colour, solidifying between 25° and 30°, and exhibiting a haracteristic odour.

Physical and chemical characters.—Fat: Specific gravity at 00°, 0·8542; acid value, 42·75; saponification value, 191·8;

Reichert-Meissl value, 1·61; titration number of insoluble volat acid $\frac{1}{10}$ KOH 0·37; iodine value, 58·58; unsaponifiable, 1·1; butyr refractometer at 25°, 74°. Fatty acid (insoluble) per cent. 93· melting point, 54·4°, iodine value, 57; neutralisation value, 188· mean molecular weight, 297·3. (A. K. Menon.)

Schleichera trijuga, Willd.

The lac tree, Kosumba, or the Ceylon dak, occurs in the d deciduous forests over the greater part of India, Burma and Ceylo Vern.—*Kusum*, Hind.; *Paka*, Beng.; *Kon*, Cing.; *Ketjatk* Celebes.

Macassar oil is the fat obtained from the seeds of this tre Within the last few years there has been an extensive demand fro abroad for these seeds, and they have been collected from Oris under the name of Paka seeds. The seed consists of 40 per cent. shells and 60 per cent. of kernels. The latter yield about 60 p cent. of oil which is equivalent to about 36 per cent. of the nu The fat forms at the ordinary temperature a yellowish-white, butte mass. It consists chiefly of the glycerides of lauric, palmiti arachidic, oleic acids, and contains also small quantities of acet and butyric acids. Most samples of Macassar oil contain sma quantities of hydrocyanic acid, probably liberated by the action an enzyme on a cyanogenetic glucoside in the seed.

The oil has been examined by several chemists: Dr. L. va Itallie and Dr. K. Trummel in 1889, Mr. R. Glenk in 1893, a Dr. J. J. A. Wijs in 1900. The following are the chief constants Melting point, 22°; specific gravity at 15°, 0·924; acid value, 6·2- 35·4; saponification value, 215·3—230; iodine value, 48·3—69· Reichert-Meissl value, 9. Fatty acids: Melting point, 54°, 55° iodine value, 58·9; neutralisation value, 191—192. (See *Agricu tural Ledger*, No. 1 of 1905.)

ANACARDIACEÆ.

Anacardium occidentale, Linn.

Cashew nut tree. The kernels yield a light, yellow, bland o Niederstadt (1902) found the saponification value to be 179·84, a the iodine value, 60·6.

The pericarp or shell yields a black, acrid and powerful vesicating oil. Crossley and Le Sueur determined the followi constants: Specific gravity, 0·9594; saponification value, 45·

iodine value, 294·2; Reichert-Meissl value, 1·26. Though it possessed an abnormally high iodine value, practical experiments showed it to be a non-drying oil. This particular sample had evidently suffered decomposition.

Buchanania latifolia, Roxb.

The tree grows in the United Provinces, Coromandel and Malabar. *Chironji, piyál,* Hind.; *Charolia,* Mar.

The seeds are an article of commerce and have been in use from a remote period in the preparation of sweetmeats. The kernels are brown and mottled with darker brown, and laterally compressed like vetch seeds. They yield 58·6 per cent. of oil (Church), which commences to congeal into a white semi-solid mass at 18·5°.

Crossley and Le Sueur obtained the following constants: Specific gravity at 100°, 0·8942; melting point, 32°; acid value, 15·4; saponification value, 193·6; iodine value, 57·3; Reichert-Meissl value, 0·33; refractive index, 1·4584; insoluble acids and unsaponifiable, 95·8 per cent.

Mangifera indica, Linn.

Mango kernels are somewhat astringent and contain about 15 per cent. of fat. J. Sack, in 1911, found the fat to melt at 36°, and to have the following constants: Acid value, 12·3; saponification value, 175; iodine number, 54·5; Reichert-Meissl value, 0·2. The bulk of the fat, according to this investigator, consists of oleodistearin.

Pistacia vera, Linn.

The Pistachio nut tree grows in Afghanistan and Persia, and the nuts are imported in large quantities into India. According to Church a sample of the kernel from Afghanistan contained 62·5 per cent. of oil, which is 11 per cent. more than in European kernels. The oil obtained by extraction with ether has a more pronounced aromatic odour than that expressed in the cold. Pistachio oil has a very limited commercial application, the nuts being used for edible purposes and in the manufacture of sweetmeats.

Physical and chemical characteristics: Specific gravity at 15°, 0·9185; solidifying point, – 8° to – 10°; saponification value, 191·3; iodine value, 86·8—87·8; Maumené test, 44·5—45; butyro-refractometer at 25°, 62°. Fatty acids: per cent. 96·1; melting point, 17°—20°; iodine value, 88·9, 96·2. Fabris and Settimj give the

iodine value 92·5 and Maumené test 55° for an oil obtained by expression of Sicilian seeds. The oil yielded 80 per cent. of liquid fatty acids of the iodine value 105·8.

MORINGEÆ.

Moringa pterygosperma, Gaertn.

The Horseradish tree is common in India and is used chiefly for its pods and root; the former as a vegetable and the latter as a substitute for horseradish. The seeds yield oil of ben, which formerly had a reputation of being a thin oil suitable for fine machinery. Jamaica seeds consist of 40 per cent. of husks and 60 per cent. of kernels. The oil gave 60 per cent. of liquid oil and 40 per cent. of white solid fat. Seeds from Northern Nigeria contained 33·4 per cent. of oil. Meggitt (1907) obtained 25·65 per cent. of oil in the sweet variety and 22·62 per cent. in the bitter variety.

Lewkowitsch expressed the seed in two stages and obtained a cold pressed and a hot pressed oil. The examination of these two oils gave the following numbers: Specific gravity at 40°, 0·9018, 0·8984; acid value, 49·71, 100·5; saponification value, 179·2, 178·7; unsaponifiable matter, 1·67, 2·69 per cent.; iodine value, 100·3, 88; titer test of fatty acids, 32°, 38·2°.

Ben oil is said to consist of the glycerides of oleic, palmitic and stearic acids and of a solid acid of high melting point, probably arachidic acid.

CONNARACEÆ.

Connarus nitidus, Roxb.

Dr. McLelland states that in Rangoon the seeds of this plant yield a quantity of sweet oil. It has been occasionally reported that oil is obtained from the seeds of other species of Connarus including **C. monocarpus,** Linn., of the Western Peninsula.

LEGUMINOSÆ.

Arachis hypogæa, Linn.

The seeds of this plant are called ground-nut, pea-nut, earth-nut, monkey-nut and Chinese-nut. Although grown here and there all

over India as a garden or field crop it is only in Madras and Bombay that the ground-nut is produced on a commercial scale. The Madras area is over 500,000 acres and that of Bombay about 94,000 acres. On well managed land a crop of 3,200 to 3,500 lbs. of unhusked nuts per acre may be raised. The seeds are largely used for edible purposes, while large quantities of the seeds and oil are exported from Bombay and Madras. Leather has shown that the Mauritius variety of ground-nut contains from 44 to 49 per cent. of oil, while the indigenous varieties contain only 40 to 44 per cent. Newer samples have more recently been imported and it has been noticed that they are uniformly more rich in oil than the local kinds. These figures refer to the proportion of oil in the kernels. The proportion by weight of unhusked nuts to kernels is as 4 to 3. The bulk of the Indian manufacture of the oil is in the hands of owners of native rotary mills. Mills of the European pattern have been tried in South India, but they could not compete with the crude native mills as the cake from the former was too dry and powdery. Recently mills have been opened in Calcutta and elsewhere in Bengal for the manufacture of the oil and have created a large import traffic in the nuts. The nuts having been shelled the expression is carried out in two stages. The first expression is carried out at the ordinary temperature, and the cold drawn oil is nearly colourless, has a pleasant taste and is used as a salad oil. The second expression is made at a temperature of 30° to 32° and yields an oil suitable for edible purposes and for burning. Sometimes a third expression is made at a higher temperature and gives a turbid oil suitable for soap making. Arachis cake contains the highest amount of proteins of all known oil-cakes. That from non-decorticated nuts contains 5·35 per cent. of nitrogen and 0·9 per cent. of phosphoric acid, and that from the kernels contains 7·9 per cent. of nitrogen and 1·35 per cent. of phosphoric acid.

Arachis oil has the following constants: Specific gravity at 15°, 0·917 to 0·920; solidifying point, about zero; saponification value, 185·6 to 194·8; iodine value, 83·3 to 100; Reichert-Meissl value, 0·0; Maumené test, 49°. Insoluble fatty acids and unsaponifiable, 94·87 to 95·86; melting point, 22° to 29°; iodine value, 95·5 to 103·42; mean molecular weight, 281·8.

Arachis oil can be identified and detected by the isolation of arachidic acid, a constituent melting at 74·5°. About 10 grms. of the oil is saponified, neutralised and treated with lead acetate. The lead salt is extracted with ether and the insoluble portion is decomposed and the fatty acids dissolved in 50 c.c. of 90 per cent. hot

alcohol. On cooling the alcoholic solution a crop of crystals will be obtained which should amount to 5 per cent. of the oil and melting between 74° and 75·5°.

Butea frondosa, Roxb.

The seeds contain 18·2 per cent. of fat (Waeber, 1886). The oil is yellow, nearly tasteless and solidifies at 10° (Lepine). Brannt records the specific gravity at 0·927.

Cæsalpinia digyna, Rottl.

This plant is called "Teri" in Assam and "Sim-let-the" in Burma, and the pods are a valuable tanning material. Dr. Roxburgh named the plant **C. oleosperma** on account of the oily nature of the seeds. The powdered seeds yield to ether 25·3 per cent. of a thick light coloured oil worthy of further investigation.

Glycine hispida, Maxim.

Syn. **Soja hispida,** Sieb. et Zuc. A plant indigenous to China, Manchuria, Korea, Japan and Indo-China.

Soy beans yield soy-bean or Chinese-bean oil, and the industry forms one of the most important manufactures of Manchuria and Japan. The seeds contain about 18 per cent. of oil and 30—40 per cent. of proteins, and the oil and expressed cake are largely used for edible purposes. Soy beans are cultivated to a small extent in India. A black seeded indigenous kind, grown in the United Provinces, yields between 16 and 17 per cent. of oil. Imported seeds grown in Poona and the Himalayas afford about 20 per cent. of oil.

The oil has been examined by Morawski and Stingl, de Negri and Fabris, and Shukoff with the following results: Specific gravity at 15°, 0·924—0·927; solidifying point, +8° to +15°; saponification value, 190·6—192·9; iodine value, 121·3—124; Maumené test, 59—61; fatty acids and unsaponifiable, per cent. 95·5; melting point, 27°—29°; iodine value, 115·2—122, of liquid fatty acids **131.**

The proportion of solid fatty acids in the oil is approximately 11·5 per cent. of the total mixed fatty acids. The bulk of the solid

fatty acids is stated to be palmitic acid; the liquid acids consist of oleic and linolic acids. On exposure to the air the oil dries slowly with the formation of a thin skin. (The Soy bean in India, *Agricultural Ledger*, No. 3 of 1911.)

Pithecolobium dulce, Benth.

The Inga bean. A medium-sized, evergreen tree introduced from Mexico. *Vilati*, Hind.; *Amli*, Bomb.; *Korukapilly*, Tam.

The black, shining seeds are half enveloped in a white edible pulp or aril. The pulp on extraction with ether yielded 18·22 per cent. of a yellowish oil, which solidified at a temperature of 15°. The expressed oil is yellowish-white and very viscous, depositing "stearin" on standing.

Physical and chemical constants.—Fat: Specific gravity at 100°, 0·9106; acid value, 63·9; saponification value, 205·9; Reichert-Meissl value, 8·41; titration number of insoluble volatile acids, $\frac{1}{10}$ KOH 0·34; iodine value, 56·6; unsaponifiable, 1·17; butyro-refractometer at 25°, 69·5. Fatty acids: per cent. 87·64; melting point, 44·7°; iodine value, 57·59; neutralisation value, 198·7; mean molecular weight, 282·2. (A. K. Menon.)

Psoralia corylifolia, Linn.

A common weed throughout India. *Babachi, baranchi*, Hind.

The seeds are ovate, of a dark brown colour, and have an aromatic odour and bitter taste. They are used for skin diseases. The seeds yield 20·15 per cent. of a thick, reddish-brown oil to ether.

Fat: Specific gravity at 100°, 0·9107; acid value, 39·18; saponification value, 204·6; Reichert-Meissl value, 6·9; iodine value, 79·9; unsaponifiable, 1·73; butyro-refractometer at 25°, 79·5°.

Fatty acids (insoluble): per cent. 88·3; melting point, 32·8; iodine value, 83·06; neutralisation value, 192·4; mean molecular weight, 291·5. (A. K. Menon.)

Pongamia glabra, Vent.

A tall tree growing all over India, especially near the coast; also in Ceylon, Malayan Archipelago and Northern Australia. Vern.—*Karanj*, Hind.; *Pungam*, Tam.; *Honge*, Kan.

The oil is used for skin diseases and rheumatism, and for illuminating purposes. It is a thick oil, of a light orange-brown colour, with a bitter taste, probably due to a resin. By extracting the kernels with ether 33·7 per cent. of a buttery mass of a dirty yellowish colour was obtained. The residual cake contains 23·3 per cent. of proteins. Should a demand arise for this oil it could be obtained to an unlimited extent in Bengal.

Lewkowitsch (1903) observed the following constants in a sample obtained from India: Specific gravity at 15°, 0·9369; free fatty acids as oleic acid, 0·5; saponification value, 183·1; iodine value, 89·4; Reichert-Meissl value, 1·1; unsaponifiable matter, 6·96; insoluble fatty acids, titer test, 44·4°. Oil extracted from the seeds by ether: Specific gravity at 40°, 0·935; acid value, 3·05; saponification value, 178; iodine value, 94; unsaponifiable matter, 9·22 per cent.

Tamarindus indica, Linn.

Tamarind seeds are used as an article of food in India in times of scarcity. They contain 4·5 per cent. of oil, and the kernels 6·6 per cent. The oil is thick and light yellow in colour. It solidifies at 15° and has an iodine value of 87·1. The fatty acids melt at 46° and contain arachidic acid.

Xylia dolabriformis, Benth.

Pyinkado or Ironwood tree of Burma. The hard seeds of this tree yield to ether 21·1 per cent. of a yellow non-drying oil melting at 22°. The constants obtained in the Indian Museum were: Acid value, 22·0; saponification value, 176·3; iodine value, 89·4; fatty acids and unsaponifiable, 93·3 per cent., melting at 54°; neutralisation value, 179·4. 31·6 per cent. of the lead salt was insoluble in ether, and the liberated fat acid melted at 69°, consisting probably of stearic acid.

The following plants of this natural order afford small quantities of oil or fat:—

Acacia concinna, DC.

Soap bean or "Sikki kai" of South India. Seeds contain 1·4 per cent.

Dalbergia cultrata, Grah.

"Yindaik" of Burma. Seeds yield 4·5 per cent. of a greenish, thick, non-drying oil.

Dalbergia Sissoo, Roxb.

The seeds give 9·1 per cent. of oil.

Ormosia tavoyana.

Seeds yield 2·25 per cent. of oil.

Psophocarpus tetragonolobus, DC.

Goa beans yield 15·4 per cent. of oil.

Bauhinia sp.

Certain species of this plant are said to yield oil seeds, but nothing definite is recorded.

ROSACEÆ.

Cydonia vulgaris, Pers.

The seeds of the quince, cultivated in Asia and Europe, contain about 15 per cent. of a fatty oil of yellow colour, and of a pleasant odour faintly resembling that of almond oil. Hennmann (*Arch. d. Pharm.*, 1899, 237, 358) obtained the following analytical factors: Specific gravity at 15°, 0·922; solidifying point −11° to −13°; saponification value, 181·75; iodine value, 113; Reichert-Meissl value, 0·5; insoluble fatty acids and unsaponifiable, 95·5 per cent., melting at 33°—34°; liquid fatty acids, 77·3 per cent., giving an iodine value of 132·1. The oil contains a liquid hydroxy acid, $C_{17}H_{32}$ (OH) CO_2H, the dibromide of which melts at 108°; the solid fatty acids appear to be myristic acid and an isomer of pentadecylic acid.

Prinsepia utilis, Royle.

The seeds of this shrub, known as *Bhekul*, yield an oil by expression which is used in the North-West Himalaya for food,

illuminating, and occasionally in medicine. It is said to be exported in small quantities from Garhwal and Kumaon. There are two samples in the Indian Museum; one from the Kangra Valley of a bright green colour, and the other from Bashahr in the Punjab, opaque and light brown in colour. In specific gravity, iodine value and melting point of the insoluble fatty acids, the oils resemble that derived from cotton seed.

Prunus Amygdalus, Stokes.

The Almond is occasionally cultivated in **Kashmir and the** Punjab. The nuts are imported, and the kernels of the sweet variety are largely used in dessert and confectionery. Sweet almonds yield from 44 to 55 per cent. of oil, whereas bitter almonds, on an average, give from 38 to 45 per cent. Bitter almonds are more frequently used for expressing the oil, though the oil from both varieties is practically identical. Almond oil does not easily turn rancid, and is largely used for pharmaceutical purposes. The constants of this oil are: Specific gravity at 15°, 0·914—·920; saponification value, 189·5—195·4; iodine value, 94—101; Maumené test, 51·5—54; oleo-refractometer reading at 22°, + 8 to + 10·5; fatty acids, melting point 13°—14°; iodine value, 93·5 to 96·5.

The German Pharmacopœia test for pure almond oil is that the mixed fatty acids should remain liquid at 15° for an indefinite length of time.

Prunus Armeniaca, Linn.

A moderately sized deciduous tree, cultivated in the Western Himalaya, Persia, Afghanistan and Syria. The fruit called *khubanis* are imported in large quantities into Leh from Baltistan and Ladakh, and distributed over Northern India. The kernels, under the names of *giru* or *stigu,* are sold at Leh for the preparation of oil, and it is said that these seeds are sent from Asia Minor to Europe as " peach kernels," and the oil is used as a substitute for almond oil. Large quantities are exported annually from Damascus to Marseilles and Hamburg. Apricot kernels contain from 40 to 45 per cent. of an almost colourless oil which becomes yellow on keeping. Apricot oil is so similar to almond oil in its physical and chemical characters that most of the figures for these constants are of very little use for the purpose of identification. Apricot oil, however, with nitric acid, specific gravity 1·4, assumes an orange

colour, and with Bieber's reagent a peach-blossom colour is obtained. Bieber's test is carried out by agitating five volumes of oil with one volume of a mixture consisting of equal parts (by weight) of concentrated sulphuric acid, fuming nitric acid, and water. Pure almond oil does not change in colour, whereas apricot kernel oil gives a pink (peach-blossom) colour, and peach kernel a faint pink colouration after standing some time. Mixtures containing 25 per cent. of apricot oil cannot be detected with certainty by means of this test.

Prunus communis, Huds., var. **insititia.**

This tree is cultivated or indigenous in the Western Himalaya from Garhwal to Kashmir. It affords the Bokhara plum, or *alu bukhara* of Indian bazars. The oil, resembling apricot kernel oil, is prepared from the seeds, and is used for illuminating and edible purposes.

Prunus persica, Stokes.

The Peach tree is cultivated all over India. Like other species of Prunus, the kernels yield an oil, used by the natives of North-West Himalaya for cookery, illuminating purposes, and as a dressing for the hair. The kernels contain 32—35 per cent. of a pale yellow oil similar to almond oil. In Europe the oil enters into the composition of "French almond oil."

Prunus Puddum, Roxb.

The seeds of the Bird cherry growing in the Himalayas yield a peculiar oil remarkable for its siccative properties. A sample of the freshly expressed oil gave the iodine value (Hubl) 172. It dried to a skin in glass more rapidly than boiled linseed oil. The pressed cake and seeds distilled with water afforded considerable quantities of hydrocyanic acid and benzoyl aldehyde (oil of bitter almonds).

COMBRETACEÆ.

Terminalia Catappa, Linn.

The Indian or Country Almond (*Badam*, Hind.) is a large deciduous tree cultivated in most parts of India. It has been estimated

that a tree yields about 10 lbs. of kernels, and from these about 50 per cent. of oil may be obtained by extraction. The kernels are palatable and are eaten for dessert. The oil is light yellow and is similar to almond oil in flavour and odour.

The seeds in India yield a small proportion of kernel. The kernels of seeds obtained from Sibpur near Calcutta afforded 48·3 per cent. of a light yellowish brown, non-drying oil. Of late the seeds have been exported from Togo as a commercial article. Grimme, in 1910, obtained from the seeds 63·43 per cent. of oil which in odour, taste and colour resembled true almond oil. The oil did not readily become rancid, but had the drawback of becoming thick on standing and of yielding an abundant deposit of stearin. The residue from the extraction contained 59·38 per cent. of proteins.

Grimme obtained the following constants: Specific gravity at 15°, 0·9195; solidifying point, +7°; ^{n}D at 20°, 1·4682; acid value, 4·1; saponification value, 185·7; iodine value, 77. Insoluble acids and unsaponifiable, 93·95; unsaponifiable, 1·87. Fatty acids: Melting point, 48·49°; neutralisation value, 198·6; iodine value, 73·5; mean molecular weight, 282·8.

A sample examined in the Indian Museum had a specific gravity at 15° of 0·9206; acid value, 7·77; iodine value, 81·8. The fatty acids melted at 42°.

In 1907 a specimen of Badam oil, purchased in the Lucknow bazar, was sent to the Indian Museum for examination. It proved to be Poppy seed oil.

Terminalia Chebula, Retz.

The Chebulic or Black Myrobalan tree, the fruits of which are known as *hurras* and constitute one of the most valuable tanning materials of India. On removing the astringent pulp of the myrobalans a hard, stony seed remains which weighs 37·5 per cent. of the fruit. The seeds are sent in large quantities from the Central Provinces to Bombay as an oil seed. Within the seed is a kernel which yields to ether 36·7 per cent. of a yellowish, pleasant and edible oil. A sample of the oil had an acid value of 8·9, saponification value 192·6, iodine value 87·5, and 96·2 per cent. of insoluble fatty acids and unsaponifiable matter.

Terminalia belerica, Roxb.

Like other kinds of Terminalia, the Beleric myrobalans afford a yellow fixed oil which is prepared by the poorer classes in the Central Provinces and used as a substitute for ghee and as an application for rheumatism. Bahada seeds yield about 25 per cent. of oil by expression which sells for 8 annas per seer. Two samples from Akola and Damoh had the following characters: Specific gravity, ·9168, ·9193; melting points, 11°, 4°; acid values, 2·4, 3·9; saponification values, 205·8, 205·3; iodine values, 79·0, 85·3; Reichert-Meissl values, ·76, ·78; fatty acids and unsaponifiable, 94·2, 93·6 per cent., melting at 39° and 38°.

CUCURBITACEÆ.

Most of the members of the gourd family yield a bland oil, and a few of those usually available in India are noticed below. From West Africa large quantities of melon seeds are exported to Europe. China also does a considerable trade in them. In India the fruits are chiefly eaten raw or cooked and are not allowed to ripen their seeds, accordingly the supply of oil is not extensive.

Citrullus Colocynthis, Schrad.

The seeds of the wild colocynth are used for food in Sind and Baluchistan; the kernels are roasted or boiled and eaten with dates. The seeds yield to solvents about 17 per cent. of yellowish-red oil having an iodine value of 129·3, and 92·2 per cent. of fatty acids melting at 29°. Grimaldi and Prussia, in 1909, found the oil of colocynth seeds to have the specific gravity of 0·9289, solidifying point 14°, and iodine value 120·27. Power and Moore (1910) separated from the oil a phytosterol, melting between 158° and 160° C. The oil has a bitter taste if made from the undecorticated seeds.

Cucumis sativus, Linn.

Cucumber seeds are occasionally pressed for oil in the United Provinces and the Punjab. The constants of two samples were tested in the Indian Museum and found to be: Specific gravity at 15°, 0·923 and 0·924; acid value, 10·68 and 11·49; saponification

value, 195·2 and 196·9; iodine value, 117·6 and 118·5; Reichert-Meissl value, 0·52; fatty acids and unsaponifiable, 94·4 per cent.; melting point, 35·5°. The oils were yellow coloured and dried slowly on exposure.

Cucurbita maxima, Duchesne.

The squash gourd (*kudu*) is the largest known cucurbitaceous fruit, in some cases weighing as much as 240 lbs. and measuring nearly 8 feet in circumference. The seeds and the oil are used medicinally. Four samples of the oil received in the Indian Museum from Allahabad, Cuddapah, Punjab and Mandalay, were examined in 1907. The first three were yellow in colour, while the fourth was greenish-brown and fluorescent; they solidified about zero (Centigrade). The following maximum and minimum constants were noted: Specific gravity at 15°, 0·919 to 0·926; acid value, 6·38 to 17·65; saponification value, 194·9 to 197·1; iodine value, 88·7 to 133·4; Reichert-Meissl value, 0·48 to 0·67; fatty acids and unsaponifiable, per cent. 94·3 to 95·8; melting point, 32° to 38°.

Cucurbita Pepo, Linn.

The pumpkin or vegetable marrow. The seeds yield 25 per cent. of oil to solvents. The oil is greenish coloured with a slight red fluorescence, it has a pleasant odour and taste with distinct drying properties. In South Russia the oil is prepared on a commercial scale by roasting the seeds and subsequently expressing the oil in the hot. The oil has been examined by Poda (1898), Graham (1901) and others, and the constants do not differ widely from those found in the oil expressed in India.

Specific gravity at 15°, 0·923 to 0·928; solidifying point, – 16°; saponification value, 188·7 to 195·7; iodine value, 121·0 to 130·7; Reichert-Meissl value, 0·43 to 0·52; refractive index at 25°, 70·2 to 72·5; insoluble fatty acids and unsaponifiable, 94·7 to 96·2 per cent., melting at 28·4° to 32°. Power and Salway (1910) determined the composition as glycerides to be; linolic acid 45 per cent., oleic acid 25 per cent., palmitic and stearic acids 30 per cent., and a phytosterol.

The cold drawn oil and the seeds are used for edible purposes; the lower qualities of pumpkin seed oil serve as a burning oil.

Luffa acutangula, Roxb., var. **amara.**

The plant is cultivated in most parts of India, chiefly for the green fruit, which is cooked and eaten.

The seeds are small (17 weigh one gram), black, irregularly pitted and two-lobed at the base. On extraction with ether the seeds yielded 20 per cent. of a light green oil. The expressed oil is yellowish-white in colour and solidifies at the ordinary temperature in England (60° Fah., 15·5° C.).

Physical and chemical characteristics.—Fat: Specific gravity at 100°, 0·9363; acid value, 93·7; saponification value, 229·2; Reichert-Meissl value, 13·1; titration number of insoluble volatile acids, $\frac{1}{10}$ KOH 0·83; iodine value, 40·12; unsaponifiable, 1·09; butyro-refractometer at 25°, 73°. Fatty acids (insoluble): per cent. 82·3; melting point, 44·1; iodine value, 41·9; neutralisation value, 215; mean molecular weight, 260·9. (A. K. Menon, 1910.)

Luffa ægyptiaca, Mill.

A native of India, often cultivated in the plains. The oil is dark reddish-brown in colour, possesses a slight odour and is semi-drying.

Lewkowitsch determined the following constants: Specific gravity at 15°, 0·9254; saponification value, 187·8; iodine value, 108·51; Reichert-Meissl value, 1·43; butyro-refractometer "degrees," 62° at 40°; insoluble fatty acids and unsaponifiable, 94·8. Two samples examined in the Indian Museum were dark greenish in colour, had acid values of 33 and 36·4, and the insoluble fatty acids melted at 34° and 35°.

LYTHRACEÆ.

Lawsonia alba, Lamk.

The Henna plant or Mehndi is valued on account of its leaves being used in the East for staining the skin a red colour. The seeds have been reported as oily, but an authentic sample from Saharanpur examined in 1907 contained only 10·5 per cent., extracted by ether. The iodine value of the oil was 121·6 and had the drying properties of poppy seed oil.

Safflower cake forms a useful cattle-food and contains nitrogen 8·12, potash 0·93, phosphoric anhydride 1·03 per cent. (*Ann. Rep. Bombay Agric. Dept., 1909-10.*)

Carthamus Oxyacantha, Bieb.

Wild safflower occurs plentifully over the drier and sandy tracts of Northern India and is very abundant in the Peshawar district. The seeds are small, boat-shaped, thin, dark coloured and often mottled. The seeds, or more correctly, fruits, afford an oil similar to that of the Kusum or cultivated safflower, and its chief use is in the manufacture of a material for decorating Afridi wax-cloth. (See *Agricultural Ledger*, No. 12 of 1901.) *Polli* oil is boiled or heated for several hours and converted into *roghan*, before it is used for painting on cloth. On the application of heat to the naturally expressed oil, the temperature gradually rises, and at 140° C. and upwards, a pungent suffocating odour, due to acrolein, is given off. This odour is evolved while the temperature rises to 240° and 250°. After six hours the acrolein is given off in less abundance, and the oil assumes a darker colour and thicker consistence. After about 10 hours it loses altogether its oleaginous property and becomes sticky; at this stage and while still hot it is thrown into water and emulsification ensues in such a manner as to preserve its sticky nature; otherwise it would form into a jelly as it cooled and cease to flow from any vessel in which it was placed. The *roghan* prepared after this manner retains its adhesive properties as long as it is preserved in a convenient vessel, but on exposure to air such as when it is spread on any cloth material it solidifies to an insoluble waterproofing compound.

Guizotia abyssinica, Cass.

A native of tropical Africa, but cultivated as an oil-seed in most of the provinces of India. Vern.—*Kálá-tíl*, *surgúja*, *jagna*, *rámtíl*. Niger seed.

The achenes are of a greyish-black colour, about one-fifth of an inch long, somewhat angular from lateral compression, tapering towards the base, quite smooth, taste oily and nutty. They contain from 40 to 45 per cent. of a yellow sweet oil. According to Leather seeds from cultivated Indian plants yield on an average 40 per cent. of oil. The oil is used in soap-making and as a substitute for linseed oil; in India it is occasionally employed as a substitute for ghee.

Crossley and Le Sueur in 1898 examined four samples of East Indian oil: Specific gravity at 15·5°, 0·9248—0·9263; solidifies below zero; saponification value, 188·9—192·2; iodine value, 126·6—133·8; Reichert-Meissl value, 0·11—0·63; Maumené test, 81°; butyro-refractometer, 63° at 40°. Fatty acids and unsaponifiable, per cent. 94·11; iodine value, 147·5. The oil has slight siccative powers and gained 7·2 per cent. in weight in fifteen days.

Helianthus annuus, Linn.

The Sunflower is grown to a large extent in Russia, in other parts of Europe and America. The kernels are edible, and the oil on account of its palatability and sweetness is used as a substitute for olive oil. The plant is occasionally grown in India. The oil in the seeds varies from 20·5 to 31·3, and in the kernels from 33·4 to 44 per cent. The oil is limpid, of mild taste and pleasant smell, it has drying properties, but much weaker in action than those of linseed and poppy seed.

Samples examined in England have a specific gravity at 15° ranging from 0·924 to 0·926 and solidifying at – 17°. The saponification value has been found to be between 188 and 194, iodine value 120 to 135; and the Maumené test 67·5 to 75. The fatty acids consist chiefly of linolic with a small quantity of oleic acid, and melt at 23°.

Sunflower oil does not change colour with nitric acid, but cotton seed oil, if mixed with it, becomes brown with this reagent. (*Agricultural Ledger*, No. 1 of 1907.)

Vernonia anthelmintica, Willd.

A common weed throughout India. *Bakchi*, Hind.; *Káttu-shiragam*, Tam.

The seeds are about one-eighth of an inch long, cylindrical, tapering towards the base, with a brown colour and nauseous and bitter taste. They are used for the treatment of cutaneous affections and for preserving woollen goods from the attack of insects. The seeds on extraction with ether yielded 18·25 per cent. of a dark brown coloured and strong smelling oil with some resinous matter. The expressed oil is of a light yellow colour and very viscid; it deposits "stearin" on standing.

Physical and chemical characteristics.—Fat: Specific gravity at 100°, 0·9168; acid value, 58·2; saponification value, 202·88;

Reichert-Meissl value, 7·88; iodine value, 71·0; unsaponifiable, 1·79; butyro-refractometer at 25°, 75°. Fatty acids: per cent. 91·6; melting point, 35·6°; iodine value, 73·4; neutralisation value, 195·1; mean molecular weight, 287·4. (A. K. Menon.)

SAPOTACEÆ.

Bassia butyracea, Roxb.

The Indian Butter tree is found in the Sub-Himalayan tracts from the Ganges to Bhutan. The tree is called *phulwa, phulwara* or *chara.*

The seeds are brown in colour, less than an inch in length, and the kernels yield from 60 to 65 per cent. of fat. The fat has a whitish colour and agreeable odour, and is used for edible purposes. It has been recommended for the preparation of ointments. The constants are: Specific gravity at 100°, 0·86—0·89; melting point, 39°; saponification value, 190 to 194; iodine value, 41 to 42; Reichert-Meissl value, 0·44 to 1·25. Fatty acids about 95 per cent., melting at 51° to 53°. The fat consists of the glycerides of oleic and palmitic acids and a small amount of phytosterol.

Bassia latifolia, Roxb.

The Mahua tree.

Bassia longifolia, Linn.

The Illipi tree.

These species of Bassia may be considered together since the oils have a similar composition. The Mahua tree belongs to Northern and Central India while the Illipi is found in South India.

The seeds are more elongated than those of the Butter tree, being about one and a quarter to one and a half inch in length, the Illipi being thinner than the Mahua seeds. The kernels of **B. latifolia** yield to solvents 41 to 46 per cent. of a yellowish fat melting at 24°—30°, and those of **B. longifolia** contain 54 per cent. or more. The acid values sometimes reach 70. The constants are: Specific gravity at 100°, 0·86 to 0·88; saponification value, 186—194; iodine value, 58 to 64; Reichert-Meissl value, 1·6 to 1·7. Fatty acids, 93·7 to 94·9 per cent., melting at 42° to 48°; unsaponifiable matter, 1·4 to 2·2 per cent. The oil consists of olein and palmitin and probably stearin.

There is a considerable local demand for these oils, and during the last few years a foreign trade in Mahua seeds has rapidly expanded which in 1909-10 reached 784,037 cwts., valued at Rs. 46,71,329 (£311,421 18*s.* 8*d.*). The price is 5 to 6 Rs. (6*s.* 8*d.* —8*s.* 0*d.*) per cwt. The oil-cake contains saponin and is poisonous to fish and cattle, and can be employed as a manure.

Dichopsis obovata, Clarke.

A large tree of the tropical forests of Burma, called *Pinlebyin.* The seeds yield 54·65 per cent. of a white and odourless fat having the following characters: Melting point, 33°; specific gravity at 50°, ·908; acid value, 16·1; saponification value, 192·5; iodine value, 47·5. The fatty acids melted at 55°. This is a useful fat, but the seeds are not available in sufficiently large quantities to establish an export trade to Europe.

Mimusops Elengi, Linn.

Vern.—*Maulsiri,* Hind.; *Mogadam,* Tamil. A large evergreen tree indigenous to the Northern Circars, the Western Coast and Ceylon. The seeds are obtainable in fairly large quantities in Madras.

The kernel is of a yellowish-brown colour, it has a very bitter taste, and is enclosed in a strong, glossy husk. The shells form 64 per cent. of the fruits. On extraction with ether, the kernels yielded 18·47 per cent. of a yellowish-brown viscid oil. The expressed oil has a light yellowish-white colour, and stearin deposits on standing. The oil is used for cooking, burning and in medicine.

The following physical and chemical characters were obtained of the fat: Specific gravity at 100°, 0·9129; acid value, 45·5; saponification value, 213·9; Reichert-Meissl value, 10·6; titration number of insoluble volatile acids, $\frac{1}{10}$ KOH 0·68; iodine value, 66·5; unsaponifiable matter, 1·56. Butyro-refractometer at 25° C., Degrees 73·5; at 40°, 67. Fatty acids: per cent. 89·4; melting point, 35°; iodine value, 68·11; neutralisation value, 202·06. Mean molecular weight, 277·6. (A. K. Menon.)

Mimusops hexandra, Roxb.

The tree is a native of the Deccan and is cultivated in Northern India. Vern.—*Kshiri,* Hind.; *Kirni,* Bomb. The oil is used for

medicinal purposes. It is yellowish and non-drying and deposits white fats at 30°. The specific gravity at 40° is 0·905, and the acid value, 25. The constants are: saponification value, 195·4; iodine value, 72·5; Reichert-Meissl value, 0·17. Fatty acids and unsaponifiable, 95; melting point, 38°; neutralisation value, 200·5; iodine value, 75·6.

Payena oleifera.

Seeds of this tree closely resembling Bassia seeds have been sent from Burma to the Reporter on Economic Products, Calcutta. They are known as Kanswe seeds, and the kernels yield to petroleum ether 56·34 per cent. of white fat with a reddish tinge. A. K. Menon in 1910 obtained the following constants: Specific gravity at 100°, 0·9033; melting point, 29·1; acid value, 54·0; saponification value, 183·9—185·0; Reichert-Meissl value, 1·86; iodine value, 58·6; unsaponifiable, per cent. 2·03. Fatty acids: 91·65 per cent.; melting point, 40°; iodine value, 59·05; neutralisation value, 192·2. No stearic acid was detected.

OLEACEÆ.

Olea cuspidata, Wall.

This wild olive tree (*Zaitun*, Pers.) is found in Afghanistan and the North-West Frontier Province where the fruits are occasionally pressed for oil. The Commissioner of Kohat has sent to the Indian Museum samples of the oil and fruit which is said to ripen in October and November. The fruits contained very little pulp and the oil appeared to be yielded by the seeds, the kernels of which contained 31·8 per cent. This may explain the small yield of oil recorded in pressing experiments made since 1851. It has been suggested that by grafting the European species and by improved methods of extraction the yield might be improved. The oil of this wild olive has a greenish-yellow colour, and its characters resemble those of European olive oil. Crossley and Le Sueur in 1897 obtained the following constants: Specific gravity, 0·920; acid value, 5·0; saponification value, 190·9; iodine value, 93·6; Reichert-Meissl value, ·6; insoluble fatty acids, 95·14 per cent. Like olive oil it was non-siccative, but the iodine value of this sample was abnormally high. A recent sample of this oil from Kohat had a more normal iodine value of 86·1.

SALVADORACEÆ.

Salvadora oleoides, Dcne.

A small tree or shrub growing in Northern India. *Pilu, jhal,* Hind.; *Kakhan,* Mar.

The small rounded seeds yielded to ether 45·48 per cent. of a whitish solid fat, called Kakan or Khakhan oil. The oil is employed in Cutch in the manufacture of bangalas or outer garments of Cutchee ladies, being applied as a resist in the process of dyeing. It should prove of more extended use in the arts and medicine.

The following chemical and physical constants were obtained with the commercial fat: Specific gravity at 50°, 0·9084; melting point, 41°; acid value, 11·26; saponification value, 242·36; iodine value, 7·48; Reichert-Meissl value, 1·28. Fatty acids: per cent. 94·12; melting point, 40°; iodine value, 8·3; neutralisation value, 244·42. (See *Agricultural Ledger,* No. 1 of 1908.)

The oil of **S. persica** has similar properties. The oil-cake contains nitrogen 4·8, potash 2·8, and phosphoric anhydride 1·05 per cent. (*Ann. Rep., Bombay Agric. Dept., 1909-10.*)

APOCYNACEÆ.

Cerbera Odollam, Gaertn.

The tree lives in salt swamps on the coasts of India, Ceylon and Burma. The seeds are very poisonous, and were found by Plugge in 1893 to contain cerberin, a heart poison. The seeds yield 55 per cent. of a bland fixed oil, of a pale yellow colour, which is used for burning and for anointing the head. The specific gravity at 15·5° is 0·919; it affords 95·5 per cent. of fatty acids, melting at 34°.

Thevetia neriifolia, Juss.

The Exile or Yellow Oleander (*Kanir,* Hind.) is commonly cultivated as a garden shrub. The fruit is globular, slightly fleshy green, 1½ to 2 inches in diameter and contains a hard nut, light brown in colour and triangular, with a deep groove along the edge corresponding to the base of the triangle; each nut contains two pale yellow, slightly winged seeds. Dr. de Vrij obtained by expression 35 to 41 per cent. of oil, and with benzol 57 per cent.

The oil was almost colourless and had an agreeable mild taste like that of fresh almond oil. Its density at 25° was 0·9148, at 15° it became pasty, and at 13° was entirely solid. Oudemans found it to consist of 63 per cent. of triolein and 27 per cent. of tripalmitin and tristearin. The seeds contain a poisonous glucoside thevetin, and Warden has found in them a principle pseudo-indican affording a blue colouration with hydrochloric acid, a reaction which serves to distinguish them in toxicological cases.

Nerium odorum, Soland.

The seeds of the oleander contain 16 per cent. of oil which according to J. Camo (1908) has the following constants: Saponification value, 202 to 203; iodine value, 88; Reichert-Meissl value, 10·26; unsaponifiable matter, 19·5 per cent. (!).

LOGANIACEÆ.

Strychnos Nux-vomica, Linn.

The fat is obtained from the seeds of nux-vomica by extraction with ether, and is a by-product in the manufacture of the alkaloids, strychnine and brucine. The yield of the fat is about 4 per cent. (Harvey and Wilkie), 4·2 per cent. (Schroeder). The fat melts at about 29°, it has a low saponification value below 166 and 170, iodine value, 69 to 79. A considerable amount of unsaponifiable matter is present, from 12 to 16 per cent. According to Schroeder (1905) the fat contains 8·6 per cent. of solid glycerides (palmitin and arachin) and 74·5 per cent. of olein.

SOLANACEÆ.

Datura Stramonium, Linn.

Species of Datura are common in India, and all parts of the plant are poisonous. The seeds were examined in 1903 by J. W. Baird and F. E. Sleeper (*Am. Phar. Ass. Proc.*, 1903, 324) who obtained 32 per cent. of oil with the following constants: Specific gravity at 15°, 0·919; saponification value, 194; iodine value, 109·1; Reichert-Meissl value, 0·68; Hehner value, 93; melting point of fatty acids, 25·1°.

Lewkowitsch records the amount of oil in the air-dried seeds as 16·7 per cent.; according to Suzzi, the percentage of oil in the seeds of **D. Metel** is 15·27. The oil possesses feeble drying properties.

Hyoscyamus niger, Linn.

The seeds of henbane yield about 35 per cent. of oil, which is yellow, slightly fluorescent, somewhat viscous, and dries readily.

Nicotiana Tabacum, Linn.

The seeds of tobacco yield on pressing 9 to 10 per cent., and, by extraction, 30 to 32 per cent. of a greenish-yellow oil. It is said to have strong drying powers. The fatty acids are stated to consist of 25 per cent. of oleic acid, 15 per cent. of linolic acid, 32 per cent. of palmitic acid, and a small quantity of stearic acid.

PEDALINEÆ.

Sesamum indicum, DC.

Til, sesame or gingelly oil is one of the most valuable Indian vegetable oils; it keeps for a long time without becoming rancid and is produced in large quantities in almost every part of the Peninsula. The area under which it is cultivated is about 4,000,000 acres, in addition to over 500,000 acres where it is grown as a mixed crop; the yield in tons is about 300,000. Bombay exports almost the entire quantity produced in the various provinces, Marseilles taking the largest consignment. The seed is somewhat smaller than linseed and is white, black, red or brown in colour. Regarding the amount of oil in the seed, Leather found that the variation is from 48 to 52 per cent. though some specimens contained as much as 56 per cent. and some as little as 45 per cent. These differences appear to be independent of variety, province or climate. From 42 to 48 per cent. of oil may be obtained by expression. The seeds also contain about 3 per cent. of nitrogen and the cake is an excellent cattle-food. If made from unsound seed the cake may be used as a manure.

Sesame oil has been frequently examined by chemists, and the following average constants are quoted: Specific gravity at 15°, 0·923 to 0·926; solidifying point, – 5°; saponification value, 187·6 to 194·6; iodine value, 103 to 115; Reichert-Meissl value, 1·2; Maumené test, 63° to 65°; butyro-refractometer at 25°, 68·0; insoluble fatty acids and unsaponifiable, 95·7; melting point, 25° to 30°; neutralisation value, 196 to 201; mean molecular weight, 286.

Sesame oil contains, according to Farnsteiner, 12·1 to 14·1 per cent. of solid acids, and according to Lane 78·1 per cent. of liquid

fatty acids. These consist of oleic and linolic acids. Sesame oil is dextro-rotatory, a property which may be used as an additional means of identifying the oil. The Indian oil has a lower rotation than African. The amount of unsaponifiable matter in sesame oil varies from 0·95 to 1·32 per cent. and contains phytosterol, sesamin and a so-called red oil. The phytosterol recrystallised from alcohol melts at 139°—139·2°. In 1891 Tocher extracted from the oil, by means of glacial acetic acid, a crystalline substance named sesamin. This melts at 118° and assumes a green and then bright red colour with nitro-sulphuric acid. An extremely characteristic colour reaction, called Baudouin's test, is now used to detect the presence of sesame oil in mixtures with other oils. The test is applied as follows: Dissolve 0·1 grm. of sugar in 10 c.c. of hydrochloric acid of specific gravity 1·19 in a test tube, add 20 c.c. of the oil to be tested, shake thoroughly for one minute and allow to stand. The aqueous solution separates readily, and in the presence of even the smallest quantity of sesame oil, it will be found coloured crimson.

LABIATÆ.

Perilla ocimoides, Linn.

A plant of the labiate family indigenous to India, China (Manchuria) and Japan. In India it is found in the tropical and temperate Himalaya from Kashmir to Bhutan. The oil which occurs to the extent of 35 to 43 per cent. in the nuts, and resembles linseed oil in taste and odour, is used for edible purposes and for burning. In Japan it is employed for mixing with lacquer and for extracting the large quantities of Japan wax from the berries. The seeds are eaten by the hillmen of the North-West Himalaya and the oil is expressed.

The oil has the highest iodine value of any known fatty oil, but its drying power is inferior to that of linseed oil, although it absorbs up to 20·9 per cent. of oxygen.

A specimen examined by Wijs (1903) contained 0·48 per cent. of free fatty acids, and had the following constants: Specific gravity at 20°, 0·9306; saponification value, 189·6; iodine value, 206·1. The fatty acids melted at – 5°, and had a neutralisation value of 197·7 and iodine value of 210·6.

The oil contains linolenic acid or an isomeride of the same. (T. Kametaka, 1908.)

Origanum vulgare, Linn.

The minute seeds of this plant abundant in the temperate Himalaya have been reported as oleaginous. A sample from Ramnagar, United Provinces, yielded to ether 27·3 per cent. of a light coloured drying oil. The oil had an acid value of 11·3, saponification value 194·9, iodine value 190·5. The oil therefore resembles in properties that of **Perilla ocimoides.**

AMARANTACEÆ.

Celosia argentea, Linn.

The seeds of this common annual are used in food and medicine. Dr. A. Campbell observes that the Santals extract a medicinal oil from them. The amount of oil extracted by ether amounts to only about 7 per cent.

The seeds of **C. cristata,** Linn. afford a greenish-brown, drying oil, with an iodine value of 126·3. The insoluble fatty acids melt between 27° and 29°.

CHENOPODIACEÆ.

Spinacia oleracea, Linn.

The seeds of spinach are reported to yield a fatty oil.

MYRISTICACEÆ.

Myristica canarica, Bedd.

A large tree of the Western Ghats affords seeds (*pindi-kai,* Kan.) which are crushed and moulded into candles. The entire seeds yield 49·4 per cent. of fat, the kernels 64·7, and the mace 54·6 per cent. The fat of the seeds is light brown and crystalline, giving a carmine colour in the cold with strong sulphuric acid.

Constants: Melting point, 37·5°; acid value, 37·0; saponification value, 215; iodine value, 26·6; fatty acids, 92 per cent., melting at 41°; neutralisation value, 217.

The fatty acids probably consist of 70·8 per cent. of myristic acid and 29·2 per cent. of oleic acid.

Myristica malabarica, Lamk.

The seeds of this tree are known as Bombay nutmegs or *kaiphal*, the arillus as Bombay mace or *rampatri*. The seeds contain 40·7 per cent. of fat, and the mace 63·2 per cent., in each case the fat is associated with a red resin. Bombay mace differs entirely in its composition from that of genuine mace (**M. fragrans,** Houtt.). According to Arnst and Hart (1893) the former contains 61·05 per cent. of fat and only 0·27 per cent. of essential oil, while the latter contains only 26·78 per cent. of fat and 4·12 per cent. of essential oil.

This difference is observed not only in the composition of the crude material, but also in the characters of the separated fats. E. Spaeth in 1895 determined the constants of the fat from Bombay mace and compared them with those of genuine Banda mace with the following results:—

	Bombay.	Banda.
Melting point	31°	25° to 26°
Iodine value	51·3 to 53·5	78 to 80
Saponification value . . .	189·4 to 191·4	170 to 173

It would seem that both these fats contain myristin and olein in varying proportions. (*Agricultural Ledger*, No. 3 of 1907.)

LAURINEÆ.

Actinodaphne Hookeri, Meissn.

This tree occurs in the Konkan and Kanara. The oil of the seeds, like that of **L. Stocksii,** is called *pisa-taila*, and has similar properties and composition.

Litsæa Sebifera, Pers.

(Syn. **Lepidadenia Wightiana,** Nees., **Tetranthera laurifolia,** Jacq.)

Tree is called Miri by the Maratha peasantry. The seeds yield a solid white fat called in Java Tang kala fat. The fat melts at 42° and has acid values ranging from 3·3 to 8·8; specific gravity at 41°, 0·8734; saponification value, 268·2; iodine value, 2·28; Reichert-Meissl value, 1·47; Hehner value, 76·1. The fat appears to contain olein 2·6, laurin 96·0 per cent. A. Schroeder (*Archiv. Pharm.*, 1905, 243, 628).

Litsæa Stocksii, Hook. f.

A tree of the hilly districts of the Konkan and Kanara. The oil of the seeds is called *pisa-taila*, and is used as an application for sprains and itch. The seeds contain 31·6 per cent. of fat extracted by ether. The fat melted at 39° and afforded white crystals melting at 42·5°, consisting of lauric acid.

Litsæa zeylanica, Nees.

The tree is frequent on the Nilgiri Hills in Southern India. The seeds afford 61 per cent. of a cream coloured fat melting at 40°, with an acidity of 10. The constants are: Specific gravity at 40°, 0·9317; saponification value, 244·7; iodine value, 46·5; fatty acids and unsaponifiable, 91·3 per cent., melting at 40°. The fat consists largely of laurin.

Litsæa consimilis, Nees. (Syn. **L. zeylanica,** Nees.)

A small evergreen tree met with in the Himalayas eastward of Simla. An oil is extracted from the fruit and used for burning (*Gamble.*)

Litsæa?

The oil of the seeds (*Balong*, Malay) is one of the most expensive native oils. It is a solid crystalline fat possessing a powerful and pleasing odour like methyl-salicylate. (*Agric. Bulletin of the Straits*, Vol. VII, 1908, 175.)

EUPHORBIACEÆ.

Aleurites moluccana, Willd.

The candle-nut tree is distributed over the tropics of the Eastern hemisphere, and is found naturalised in many parts of India. Throughout the Malayan Archipelago the nuts are an article of export. The fruits resemble ordinary walnuts in appearance, and are called *jangli akrot* or wild walnuts. They consist of two-thirds of shell and one-third of kernel; the kernels contain 60 or more per cent. of oil. The cold-drawn oil is limpid, colourless or yellowish, has a pleasant odour and bland taste, but cannot be used for edible purposes on account of its purging properties. It is a good but rather

slow-drying oil, and is prized for burning, lubricating and soap-making. Its constants, according to Dunstan and Lewkowitsch, are: Specific gravity, ·9274, ·9256; saponification value, 204·2, 192·6; iodine value, 139·7, 163·7; titer test of fatty acids, 17·8°, 21°.

The tree has been recommended for planting in avenues, and the seed as a source of drying oil. (*Agricultural Ledger*, No. 4 of 1907.)

Chrozophora verbascifolia, A. Juss.

In 1906 the Political Agent at Koweit sent to the Reporter on Economic Products a sample of oil from Tannoom seeds and stated that it had appeared as a new article in the market. It was said to be employed by the Bedouins of Arabia as a substitute for ghee. The seeds were ultimately identified as belonging to this plant; they yielded to ether 35 per cent. of a rather thick, yellowish drying oil.

A preliminary examination of a small sample showed the following constants: Acid value, 3·3; saponification value, 200·2; iodine value, 137·0; melting point of fatty acids, 30·5°.

Croton Tiglium, Linn.

This tree is indigenous in Southern India and is cultivated in Southern Asia and China. The seeds contain 53—56 per cent. of oil, known in commerce and medicine as croton oil.

The oil has an amber-yellow, orange or brown colour, according to its age, a nauseous odour, a burning taste, and is a very powerful purgative. It is partly soluble in absolute alcohol and entirely so in petroleum ether. It has weak drying powers and thickens somewhat on exposure to air, and is strongly dextro-rotatory. Croton oil is stated to contain the following fatty acids: Stearic, palmitic, myristic, lauric, valeric, butyric, acetic, formic, oleic, linolic and tiglic. Its purgative principle, according to Dunstan and Boole (1895), is a neutral resinous substance possessing a strong vesicating action.

The constants of the oil are: Specific gravity at 15°, ·937 to ·943; solidifying point – 7°; acid value, 7·9 to 30·9; saponification value, 192 to 215; iodine value, 101·7 to 109·1; Reichert-Meissl value, 12·1 to 14·4; oleo-refractometer degrees at 22°, + 35°; insoluble acids and unsaponifiable, 88·9 to 89·1; solidifying point, 18° to 19°; unsaponifiable, ·55 per cent.; neutralisation value, 201.

Croton oil if adulterated with castor oil can be recognized by its higher specific gravity and lower iodine value. It should yield no solid product with the elaidin test.

Croton oblongifolius, Roxb.

The seeds afford an oil. Flückiger and Hanbury remark they are sometimes substituted for those of **C. Tiglium.**

Euphorbia dracunculoides, Lamk.

A much branched annual, with acrid properties, met with in the Punjab and Bengal (*Jy-chu*, Beng.). The seeds yield a limpid, clear, yellowish or greenish-yellow oil, used as a drying oil and for burning. In 1843 it was pronounced in London to be as valuable as linseed oil. It is only used locally.

Jatropha Curcas, Linn.

An evergreen shrub, indigenous to America, but cultivated in most parts of India. The Physic nut. Vern.—*Bag-berenda, safed arand, rattan-jot.* The seeds yield about 34 per cent. of oil and the kernels about 52 per cent. The oil is yellow when fresh, becoming reddish on exposure to the air; it has an unpleasant odour, and strong purgative properties, more pronounced than those of castor oil. Curcas oil yields about 10 per cent. of solid fatty acids melting at 57·5°; the liquid fatty acids consist of about equal proportions of oleic and linolic acids. The specific gravity is 0·919 to 0·921; saponification value, 193·2; iodine value, 98·3 to 104·9; Reichert-Meissl value, 0·55; Maumené test, 65 to 68°. The fatty acids (95·5 per cent.) melt at 24—26°; iodine value, 105.

The oil is used in medicine, for soap-making and as illuminant; it has considerable drying properties, though not so good as those of cotton seed oil.

Jatropha glandulifera, Roxb.

A small evergreen tree common in Burma, Bengal, Northern Circars and Deccan.

On extraction with ether the seeds yielded 21·3 per cent. of a light straw-coloured oil which was turbid at 55° F. The seeds form 29·8 per cent. of the capsules. Like other oils of this family it is employed as a purgative and is considered a remedy for ulcers and ringworm.

The following characters were found.—Fat: Acid value, 15·79; saponification value, 194·5; Reichert-Meissl value, 4; unsaponifiable, 1·38; butyro-refractometer at 25°, 76·5°. Fatty acids: per cent. 89·01; melting point, 35°; iodine value, 119·6; neutralisation value, 187·3; mean molecular weight, 299·4. (A. K. Menon.)

Putranjiva Roxburghii, Wall.

The seeds yield a rather turbid oil of an olive brown colour, which on standing deposits the more solid portion. It is used for burning. In 1905 the seeds were tested in the Indian Museum and found to give 28·86 per cent. of kernels and the kernels yielded to ether 42·9 per cent. of a clear light yellow oil.

Ricinus communis, Linn.

The castor oil plant is cultivated throughout India and naturalised near villages; it is probably indigenous to Africa. There are numerous agricultural forms of the plant or races which may be grouped under two types: (*a*) A tall bush or small tree of perennial growth, usually planted as a hedge or in lines through fields where it affords shade to other crops. This gives a large seed. (*b*) The other is an annual plant sometimes grown as a pure crop, though more frequently in mixed cultivation. When grown with other crops the yield of cleaned seed per acre is about 250 lbs., and when grown by itself 500 to 900 lbs. It is generally held that the large seeded varieties yield the best ordinary lubricating and lighting oils, and that the small seeded afford the finer grades, especially those used for medicinal purposes.

Leather has examined a large number of seeds from Madras, Bombay, United Provinces and Central Provinces, and shows that they contain from 25 to 35 per cent. of shells, and the kernels, with few exceptions, afford from 60 to 70 per cent. of oil, or 35 to 50 per cent. on the entire seed. Larger seeds as a rule contain more oil than smaller seeds. Two samples from Nairobi (British East Africa) were examined and the larger form yielded 47·35 and the smaller 43·35 per cent. of oil by extraction. Dubard and Eberhardt obtained an average of 46·19 per cent. with East Indian castor seeds, and by the ordinary crushing and heating with water about 37·4 per cent. of oil. Modern European machinery, especially in the jails and on the railways, is now largely used for crushing the seeds. The castor oil mills of Calcutta use up to an average of 700,000 cwts. of seed, drawn mainly by the railways from Bengal and from the United Provinces.

Castor oil is a colourless or pale greenish oil having a taste at first mild, then harsh. The oil is very viscous, but does not dry even when exposed in thin layers. Most commercial samples contain only very small proportions of free fatty acids, this is due to the refining process which consists in the coagulation of albuminous matters by steaming and then removing them by filtration. Castor oil

is strongly dextro-rotatory. Deering and Redwood examined twenty-three samples of Indian oil and observed that in a 200 mm. tube in a Hoffmann-Laurent polarimeter the variation was from +7·6° to +9·7°. Castor oil may be said to consist of a small quantity of tristearin, of the glyceride of dihydoxystearic acid, and to a large extent of the glyceride of ricinoleic acid.

The physical and chemical constants of the oil have been found as follows: Specific gravity at 15·5°, 0·963 to 0·964; saponification value, 177 to 184; iodine value, 81·4 to 85·3; Reichert-Meissl value, 1·1; Maumené test, 46—47; oleo-refractometer degrees at 22°, 41 to 42·5. Insoluble fatty acids: Melting point, 13°; iodine value, 86 to 88.

The high specific gravity and acetyl value and its very high viscosity afford ready means of identification. It is also miscible in all proportions with glacial acetic acid and absolute alcohol, but is nearly insoluble in large quantities of petroleum ether, kerosene and higher boiling paraffin oils. The price of castor oil is at present so low that adulteration with other fatty oils is seldom practised. The price is Rs. 10 to Rs. 16 (13*s.* 4*d.*—21*s.* 4*d.*) per maund (82⅔ lbs.) for lubricating oil, and Rs. 24 to Rs. 27 (32*s.* 0*d.*—36*s.* 0*d.*) per maund for medicinal oil.

Castor oil is valuable as a preservative and is used for leather goods of all kinds and as a lubricant for machinery. It is frequently employed by Indian dyers as an auxiliary in certain tinctorial operations and by calico printers. Turkey red oil is manufactured from it and is used in mordanting alizarin dyed fabrics and for dressing tanned leather. Medicinally the oil holds an important position as a purgative. Lastly castor-oil cake is rich in nitrogen and phosphoric acid and is in much demand as a manure for potato and sugar-cane.

Sapium indicum, Willd.

This small evergreen tree of the Sunderbans is related to the Chinese Tallow tree. The kernels afford to ether 50·3 per cent. of a thick greenish-yellow oil, which, when smeared on glass, dried to a skin in two days. The iodine value was 130·4. This oil is worthy of further notice.

Sapium sebiferum, Roxb.

The Chinese Tallow tree is a small glabrous tree, indigenous and cultivated in China and Japan, and introduced into and cultivated in

Northern India. A hard white fat surrounds the coats of the seeds, and the kernels contain a brownish-yellow drying oil called stillingia oil. Efforts have been made to utilise the tallow in India, but the labour and expense involved in extraction are said to be far in excess of the value of the product. Further information will be found in *The Agricultural Ledger*, No. 2 of 1904.

URTICACEÆ.

Cannabis sativa, Linn.

Indian Hemp is grown for its intoxicating drugs, ganja and bhang, but no special use appears to be made locally of the seeds. Hemp seeds yield from 25 to 30 per cent. of a light green or greenish-yellow oil becoming brownish-yellow on keeping. The specific gravity is from ·925 to ·931; saponification value, 190 to 193; iodine value, 144 to 166; the fatty acids melt at 17° to 19°. It is used on the Continent as a paint oil and for making soft soap.

JUGLANDEÆ.

Juglans regia, Linn.

The Walnut (*Akrot*, Hind.) is found wild and cultivated in the temperate Himalaya from Kashmir to Assam. The kernels afford by expression about 50 per cent. of a clear sweet oil, largely used in the hills for culinary purposes and illumination. Stewart states that a large proportion of the oil is prepared by simply bruising the kernel between stones. The oil-cake is a good cattle-food. Walnut oil has a yellow or orange yellow colour with a slight odour of linseed and a nutty flavour. Practical experiments show it to be a strong drying oil. Crossley and Le Sueur (1898) testing a sample expressed in India found it to have constants agreeing well with those previously recorded: Specific gravity at 15·5°, 0·9259; acid value, 10·07; saponification value, 192·5; iodine value, 143·1; Reichert Meissl value, 0·00; insoluble fatty acids, 95·44 per cent.

CONIFERÆ.

Pinus Gerardiana, Wall.

The seeds of Gerard's pine, known as chilgoza or neoza nuts, are a commercial article in Northern India, and yield 30·7 per cent.

of a very viscous, greenish-yellow oil. Grimme (1911) obtained the following constants: Specific gravity at 15°, 0·9307; solidifying point - 17°; acid value, 1·6; saponification value, 191·3; iodine value (Wijs), 118·3. Fatty acids, 91·46; unsaponifiable matter, 1·64; melting point, 0°; solididying point - 3°; iodine value (Wijs), 125·0; neutralisation valu, 196·7; mean molecular weight, 285·2.

PALMÆ.

Cocos nucifera, Linn.

Coconut oil constitutes the most important in quantity and value of all the oils exported from India. During the past three years the amount has been on the average 2,500,000 gallons and the value Rs. 37,50,000 (£250,000), this represents one-half of all the vegetable oils sent out of the country. The coconut palm grows most abundantly along the Malabar coast, and the oil produced in Cochin has maintained a very high reputation in the market for many years. The oil was originally prepared by boiling the kernels with water and skimming off the oil, a considerable quantity was also made in crude native mills by expression, but during latter years modern machinery has been introduced such as is used in Europe. The use of freshly dried kernels ensures the production of an oil containing little acidity.

Coconut oil is light coloured oil with a bland taste and a peculiar but not unpleasant odour. In the winter months when the temperature falls to 22° to 24° it solidifies to a white fat. The oil may be easily purified and in this state it forms a favourite edible oil. Coconut oil is used in enormous quantities in the manufacture of soaps, made by the boiling process, as also by the cold process; the crystalline character of the fat renders it suitable for toilet preparations. The oil is employed extensively as a vegetable butter and as a chocolate fat. Coconut oil resembles palm oil in its chemical composition; like the latter it contains large proportions of trimyristin and trilaurin, smaller quantities of the palmitin, tristearin, and triolein, as also the glycerides of the volatile acids caproic, caprylic and capric. It is practically free from hydroxy acids (Lewkowitsch), and free from butyric acid.

Crossley and Le Sueur (1898) obtained the following constants in oils received from Malabar, Bengal and Bombay: Specific gravity at 100°, 0·903 to 0·904; acid value, 9·9 to 35·2; saponification value, 255·5 to 258·2; iodine value, 8·25 to 8·54; Reichert-Meissl value,

6·65 to 6·79; melting point, 23·5 to 25·0; insoluble fatty acids, 82·35 per cent.

Coconut oil is rarely adulterated with other fats, and the above tests are usually sufficient for its recognition. It may be remarked that this oil has a great resemblance to the oil obtained from the kernels of the palm tree (**Elæis guineensis,** Linn.) of the west coast of Africa.

Areca Catechu, Linn.

Areca nuts contain about 14 per cent. of fat. An elaborate analysis of the fat has been made by A. Rathje (*Archiv. de Pharmazie*, 246, 9, 1908, 703), in which it appears to resemble coconut oil, but the extensive use of the nuts in the East as a masticatory precludes this oil from reaching any commercial importance.

GRAMINEÆ.

Oryza sativa, Linn.

Unmilled rice contains between 2 and 3 per cent. of oil, but in the process of polishing most of this oil is removed with the aleurone layer. The bran from rice mills in Rangoon and elsewhere contains a considerable amount of oil which frequently amounts to 20 per cent., and for this purpose is exported from India to Europe for supplying a material in soap manufacture. On account of the presence of an enzyme in the bran, the oil extracted has usually a high acidity. A recent analysis of rice oil has been published by M. Tsujimoto (1911) recording the following physical and chemical characters: Specific gravity at 15°, 0·927; acid value, 34·75; saponification value, 184·87; iodine value (Wijs), 107·6; unsaponifiable matter, 4·78. Fatty acids: melting point, 32·5°; neutralisation value, 197·6; iodine value, 107·82. The approximate composition of the total fatty acids was calculated as, palmitic 20, oleic 45, isolinolic 35.

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TO

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